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REPORT ON A PROJECT

FOR

THE SUPPLY OF WATER

TO THE

POONA CANTONMENT.

BY

CAPTAIN PHILIP LEWIS HART,

BOMBAY ENGINEERS.

With Plans and Sections

(In a Separate Case).

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INDEX.

APPENDIX.

REPORT

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SUPPLY OF WATER TO THE POONA CANTONMENT,

BY

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"To select and mature the most promising of the various schemes either already submitted, or which he (the Officer deputed on the duty) might himself find it expedient to suggest."—*Extract from Chief Engineer of Public Works' Letter to Government, No.* 10211 *of* 1856, *dated* 20*th December, paragraph* 16.

1. The following are the various schemes which have been already submitted for supplying the Poona Cantonment with water; but they are all, more or less, so mixed up with the supply to the City of Poona, that I have been unable to separate them, although the former is the subject with which I have to deal in this Report.

2. Captain Jacob's proposal (dated 4th December, 1851) was for increasing the supply of water to the City of Poona by removing the *supposed* deposit from the Lower Kartriz Tank.

3. Captain Graham's projects (dated 31st October, 1851) for supplying the City of Poona and the Cantonment are as follows:—*For the City of Poona.* 1*st.* By increasing the supply of water at the Lower Kartriz Tank in different ways. By raising the wall of the Kartriz Tank, at an estimated cost of Rs. 18,402. For increasing the supply in the Kartriz Tank, by conveying the water from the upper to the lower tank; and by the construction of various masonry aqueducts to catch the water from a certain Nullah and supposed spring, at an estimated cost of Rs. 66,704. 2*nd.* By constructing

sluices at the Sangroon, Kanapoor, and Gorleh Dohoos, or natural lakes, in the Mootta River twelve miles west of Poona, and allowing the water therefrom to flow down the bed of the river to Poona: this project does not appear to have been estimated. *3rd.* By increasing the supply of the Nana aqueduct: this also was not estimated.—*For the Cantonment of Poona.* *4th.* By increasing the supply of Rastiah's aqueduct in different ways. By extending the same at an estimated cost of Rs. 2,725. By doming over two wells and conveying their water to the aqueduct, at an estimated cost of Rs. 30,000. *5th.* By obtaining possession of the Chowdrey's aqueduct, and throwing the supply therefrom into Rastiah's aqueduct, and, in return, supplying that portion of the City of Poona called Vetal Peth from the Kartriz aqueduct. To collect the overflow of Rastiah's aqueduct during the monsoon into two reservoirs, one in the Civil Lines and the other near the Collector's Office, at an estimated cost of Rs. 3,755 and Rs. 4,000. *6th.* If the Chowdrey will not give up his aqueduct, to complete the supply to the Cantonment by a new Bund above the village of Great Kondwah, and building a new aqueduct from the Kondwah Nullah, parallel to the Chowdrey's aqueduct; and by sinking shafts in different directions in the hot weather, with the view of finding out springs, and conducting them to the main aqueduct, at an estimated cost of Rs. 1,26,886.

4. Captain Kilner's project (dated 15th January, 1852) for supplying the Cantonment and a portion of the City of Poona, consisted of bringing the water from the Upper Kartriz Tank, at an estimated cost of Rs. 1,11,887, by iron pipes into the cistern near St. Mary's Church; from this cistern to one in the Bowanee Peth, and a branch to the Malcolm Tank in the Bazar.

5. Vickajee Meerjee's project (dated 9th October, 1851) was for bringing water from a spring at Duncowree to the Bowanee Peth in the City of Poona, estimated by him at Rs. 50,000, and by Major Kilner at from Rs. 60,000 to Rs. 70,000.

6. To complete the supply from the Jamsetjee Bund Water-works, at about two lacs and forty-one thousand gallons daily for the Cantonment, Bazar, and suburbs, by steam power, at an outlay of Rs. 1,60,122.

7. Captain Berthon's scheme (dated 10th March, 1853) was to

construct an under-ground Bund of masonry across the Kondwah Nullah, for the supply of the Cantonment, with an arched gallery, to be incorporated with the masonry of the Bund, to act as filterer and receiver. From the receiver, the water is to be carried in a 15-inch main to a central cistern, or to some convenient position in or near the Horse Artillery Lines, whence it is to be led by branch pipes to the Barracks, and other public places of resort requiring a supply, at an estimated cost of Rs. 1,23,910.

8. Mr. Reeves, the Revenue Commissioner, recommends the construction of a dam across the Mootta River between Sangroon and Gorleh, where the water of the river is retained in extensive natural reaches, called Dohoos, with iron pipes from them into the Cantonment and City; and he suggests that some of the water could be sold for irrigation.

Mr. Reeves' letter, No. 1875 of 1855, dated 3rd July; also paragraph 15 of No. 3220 of 1854. Military Board's letter, No. 1023 of 1855, dated 5th February. Chief Engineer of Public Works' report, No. 10211, dated 20th December, 1856.

9. Mr. Gerrard, Civil Engineer, proposes a scheme (dated 18th October, 1856) for the supply of the Poona Cantonment only, by damming up the Ambeygaum Valley, and leading the water in a conduit of earthenware pipes to a distributing reservoir at the back of the Hospital to the Wanowree Barracks, and thence by iron pipes to the various localities in the Camp and Cantonment Bazar, at an estimated cost of Rs. 2,48,917.

10. Before offering any remarks on the various projects above mentioned, I will premise, that a population of forty thousand (in round numbers; see Appendix, Letter A) have to be supplied daily throughout the year with twenty gallons of water per head, which is the minimum allowed for in England; and that the question of a supply of water to the Poona Cantonment involves the equally important one of a thorough drainage and sewerage of the whole site; a point, however, upon which I have not been called on to report, but which must be borne in mind in connection with any efficient project of water supply. On this latter consideration alone I should have much preferred a calculation of thirty gallons per head; but, as it might perhaps be considered that I had exaggerated the wants of the Camp, in assuming the requirements at that rate, I will retain the former quantity of twenty gallons, being, I believe, as before observed, the minimum supply usually allowed for in England.

11. The quantity of water then required for forty thousand people, at twenty gallons per head, amounts to a supply of eight hundred thousand gallons daily, or two hundred and ninety-two million gallons yearly,—taken, in round numbers, at three hundred million gallons; the water being delivered into a distributing reservoir of such an elevation as to be able, when required, to flush every drain and sewer in camp which may hereafter be constructed.

12. The above are the main standards by which I consider all the foregoing projects must be compared, although it must be borne in mind that, at the time they were framed, the population was nothing like the present number of forty thousand; that the quantity, even of twenty gallons per head daily, would have been considered much in excess of the actual wants, and that the subject of the sewerage of the Camp had not become so important a matter as at present, when the population has so much increased. This is clear, as the drainage of the Camp in connection with the water supply is not noticed, that I can discover, in any of the Reports hitherto submitted.

Captain Jacob's Report.

13. This does not concern the supply to the Cantonment in the least, as it refers to the Lower Kartriz Tănk, a work specially belonging to the Municipality, for increasing the supply to the City of Poona; but I allude to it for two reasons, which I cannot pass over without remark. The first, that Major Kilner considered the filling up by deposit of the Lower Kartriz Tank an illusion; and the second, because it was considered, both by the same Officer and Captain Graham, that raising the Bund wall of the tank was a cheaper method of obtaining an extra supply of water than by excavating the *débris* out of it.

14. I can observe that, during the last seventeen years, the deposit in the lower tank has increased considerably, and is easily accounted for.* Portions of the retaining walls to the artificial supply channel

* When I was in Poona in 1839, as Assistant Superintendent of Roads and Tanks, one of these walls had been rebuilt by Lieutenant Wood, and had been carried away during the first floods which came down the supply channel. It could not be rebuilt until the monsoon moderated, and doubtless, during the period the wall remained unbuilt, large quantities of deposit found their way into the bed of the tank. Whether this has happened since I cannot say, but the appearance of different portions of the wall favours the idea that they must have been rebuilt at some time or other.

have at different periods been washed down, generally of course at the first heavy floods of the monsoon; and through the gap so created, and which could not be rebuilt during the rains, large quantities of mud have been brought down from the hills, and deposited in the bed of the tank. With respect to raising the Bund of the tank being cheaper than excavating the mud out of it, it certainly may be, if the mere excavation of the mud by manual labour from the bed of the tank, and depositing it on the banks, be intended; but, if properly managed and cared for, immense quantities might be yearly got rid of by washing it out in a liquid state through the sluices at a small cost. The evil has probably now gone too far for any arrangement of this description being of much use.

15. In the year 1841, from the 3rd of May to the 11th of June, 171 prisoners from the Poona Jail were encamped on this work, and, with the aid of some free labourers, a large quantity of the deposit then formed was washed out through the sluices in a liquid state. Since this period, as far as I have been able to ascertain, no attempt whatever has been made to get rid of any of the deposit, beyond yearly opening the sluices to allow of the first floods of the rainy season to pass off, and to close them when the feeding channel runs clear. I rather doubt whether even this has been regularly attended to. Having been some years ago an assistant to the Superintendent of Roads and Tanks in this Collectorate, and had something to do with this work, I am enabled to offer an opinion regarding the deposit formed in it, and which is still in progress in my opinion; and I have no hesitation in saying that it is rapidly filling up, like the one above it, and that it is, from long and continued neglect, becoming inefficient as a storage reservoir for water.

Captain Graham's projects.

16. Of the six projects submitted by Captain Graham, three refer to the supply of water to the City of Poona, and three to the Camp. The one relating to the bringing water from the Sangroon, Kanapoor, and Goreh Dohoos I shall hereafter offer a few remarks on; at present I will confine myself to the notice of those referring to the Cantonment supply. From a careful inspection of the works alluded to by Captain Graham, it appears to me that not one, or all the projects taken together, as regards the Chowdrey's and Rastiah's aqueducts, collecting their overflow in the monsoon, extending or uniting them, or by

doming over the wells mentioned, and conveying their water to these works, would give the supply now required, viz. eight hundred thousand gallons daily throughout the year; and supposing the supply to be sufficient, I much doubt if the water could be delivered by gravitation at such an elevation as to supply every public building in the Camp, or be made available for flushing the sewers and drains to be hereafter laid out.

17. Captain Graham's proposal regarding these two works, Rastiah's and the Chowdrey's aqueducts, was as follows (see his letter No. 2300 of 1853, dated 8th August, paragraph 2):—

"To make the matter at issue as clear and concise as possible, I must remind the Board of the nature of my proposal, which is to supply the whole of the City of Poona from the Kartriz aqueduct, and the Cantonment of Poona from the joint supply obtainable from Rastiah's and the Chowdrey's aqueducts."

Captain Graham then goes on to observe, whether the supply obtainable from these two aqueducts, added to the probable increase from new sources, will suffice; and compares his scheme with those of Major Kilner and Captain Berthon. I have taken below the most favourable results anticipated by Captain Graham from the proposed improvements to these aqueducts, which are as follows:—

19th March	3,38,798	gallons.
31st do.	2,53,496	"
April	2,11,702	"
May	1,32,345	"

After a long and somewhat tedious correspondence on the subject of these two aqueducts, the owners, Rastiah and the Chowdrey, refused to give them up to Government. (Mr. Reeves' letter, dated 15th February, No. 510 of 1856.)

18. The only other project remaining to be noticed of Captain Graham's, is that for constructing a dam above the village of Great Kondwah, and building a new aqueduct parallel to the Chowdrey's. As regards the locality for supplying the Camp, nothing could be better; its situation and distance are admirable. The levels also suit well, as the proposed site for a dam is 135·75 feet above the old Hospital Compound in front of the solitary cells, one of the

highest points in the Camp. But, if the general configuration of a valley for impounding water ought to be deep, with steep sides and surrounded by lofty hills, then the Kondwah valley does not, certainly in my opinion, answer this description. It is flat and shallow, and only bounded by lofty hills at its head, without any spurs of the slightest consideration from the main range to form its sides. I think therefore that this valley, from the above cause, is extremely ill adapted for impounding water, although in it there is a large quantity of underground drainage, fifteen or twenty wells being worked, during the hot weather, on its banks for the Pawn gardens.

19. To show how extremely shallow a valley it is generally, I would remark that the dam proposed by Captain Graham for a reservoir above the village of Great Kondwah, when raised to its greatest possible height, is only 32 feet, with a length of 1,400 feet. The estimated supply daily for the hot weather comes to seven hundred and ninety-five thousand gallons for three months, one-third of the actual contents having been taken for evaporation; but, in a flat shallow work of this description, the surface evaporation would in all probability be much greater.

Major Kilner's project.

20. I will now proceed to notice Major Kilner's project for supplying the Camp and a part of the City of Poona with water from the Upper Kartriz Tank. Major Kilner reckons the Camp population at twenty-four thousand, and the quantity to be allowed for per head at eight gallons. The quantity required, therefore, is one hundred and ninety-two thousand gallons daily, to which is to be added, for the Horse Artillery horses about four thousand gallons, and for Sir Jamsetjee Jejeebhoy's premises five thousand gallons, making altogether two hundred and one thousand gallons. The Upper Kartriz Tank he calculates to contain forty-seven million nine hundred and fifteen thousand gallons, exclusive of all water in the deposit, with which it is about two-thirds filled up, which for 182 days, or half the year, affords two hundred and forty-one thousand two hundred and ninety-one gallons daily. In this no account is taken of the water in the deposit, or "black clay," supposed to consist of 20,430,956 cubic feet, of which probably, Major Kilner states, one-sixth is water, giving twenty-one millions, two hundred and eighty-two thousand, two

hundred and forty-three gallons in this medium. This is in addition to the daily supply above.

21. The total supply therefore, including that in the "black clay" (which has to be got at), amounts to sixty-nine millions, one hundred and ninety-seven thousand, two hundred and forty-three gallons, which would give daily throughout the year a supply of one hundred and eighty-nine thousand five hundred and eighty-one gallons, or daily for half the year three hundred and seventy-nine thousand one hundred and sixty-two gallons. Since Major Kilner's report was written, the Camp population has increased from twenty-four thousand to forty thousand, and the rate per head daily, which he calculates at eight gallons, is, without doubt, much under the mark. It is therefore very apparent that his project would not supply the present demand. I consider that Major Kilner has much underrated the evaporation. Over an area of 1,916,600 square feet, of an average depth of six feet, an extensive shallow expanse, the evaporation is only taken at one-third, or two feet of depth over the whole surface; whereas, with very little of the supply drawn off, the evaporation alone would go considerably towards emptying such a reservoir.

22. I feel satisfied, from having carefully watched this tank during the last hot season, that it cannot be depended on, in its present state, for a full and constant supply of water throughout the year. It is also to be observed that, whatever water is taken from the Upper Kartriz Tank interferes with the supply to the lower tank. This work, in fact, as much belongs to the municipality of the City of Poona as the lower tank does; and as Government are precluded (Government Resolution dated 19th September, 1855), by the express orders of the Honorable Court, from expending public money in order to provide an enlarged supply of water to the City of Poona, even supposing that the upper tank contained sufficient storage room for the supply of the Cantonment, it does not appear to me, under existing circumstances, how it could possibly be appropriated to such a purpose.

23. With reference to this Lower Kartriz Tank, which is fed to a great extent by the upper one, I would observe that the following Government buildings in the City of Poona are supplied with water from it:—

Name of Building.	Probable No. of Government servants using the water.
1. Shunwar Palace	173
2. Boodhwar do.	574
3. Nana's do.	79
4. Jail	413
Total....	1,239

24. As regards the water held in suspension by the deposit in the Upper Kartriz Tank, the quantity of it is of course a surmise; and as the difficulty of getting at it by simple means Major Kilner pronounced to be almost insurmountable, in so far as it affects that Officer's calculations, it was very properly omitted from his estimate of supply. I consider that Captain Graham has suggested the only way of getting at it, viz., by sinking deep shafts and connecting them by galleries or cuts covered over, extending over the whole bed of the deposit, and leading these channels into one or more main channels, as might be found convenient, through the Bund. What the actual supply would be by tapping this extensive water-bearing *débris*, it is impossible to say. If a very frequent inspection of this work, and a mere practical opinion be worth anything, without figures, I should say its capabilities of supply were very considerable, but that no satisfactory information could be obtained on this point, without going to some actual experiment, which, in all probability, would be attended with considerable expense.

Vickajee Meerjee's Report.

25. I have very frequently inspected the little valley of Duncowree, from which Vickajee Meerjee proposed obtaining a supply of water for a portion of the City of Poona; and, for its extent, I am of opinion that its capabilities are very considerable, but of too limited a character as an independent supply, although in any scheme which would admit of employing it as a subsidiary, it would, I am sure, be likely to prove a very valuable one.

Jamsetjee Bund Water-works.

26. There is nothing to observe regarding this work, except that it has, I believe, been abandoned as a principal source of supply, owing to the polluted nature of the water, receiving as it does, at no great distance off, the whole sewerage from the City of Poona.

Captain Berthon's scheme.

27. This project is for what Captain Berthon terms "an underground Bund across the Kondwah valley stream." There is no doubt that it would add most materially to the supply of the present Chowdrey's aqueduct. I am of opinion that it is the only work of the sort adapted to the nature of this valley. As regards the supply of water to be derived from it, it is impossible to conjecture even, but I should be inclined to doubt much if 800,000 gallons daily could be furnished from such a contrivance, in the locality indicated.

Captain Graham's and Mr. Reeves' project for bringing water from the Sangroon Dohoo.

28. These projects are the same, for bringing the water confined in the Sangroon, Kanapoor, and Goreh Dohoos, or pools in the bed of the Mootta River, for the supply of the City and Camp of Poona. I carefully inspected these pools, which are fifteen or sixteen miles south-west from Poona; their extent is as follows:—

Names of Dohoos.	Measured by Major Kilner in October and November, 1851.			Measured by Captain Hart in February, 1857.		
	Length.	Width.	Greatest Depth.	Length.	Width.	Greatest Depth.
	M. F. Yds.	Feet.	Feet.	M. F. Yds	Feet.	Feet.
Goreh Dohoo	0 7 38	222 to 425	9¼	0 6 180	250	5
Kanapoor Dohoo	0 7 93	256 to 269	11¾	1 0 100	250	6
Sangroon Dohoo	1 1 186	180 to 310	17¾	1 2 30	230	10½

29. One set of levels was taken by Mr. Gerrard, C.E., in November, 1855, and the difference of level, between the top water of the Sangroon Dohoo (the uppermost) and the top of the centre of the Jamsetjee Bund, was found to be 94·59 feet. The same levels were taken very carefully by Surveyor and Builder Venaik Bhickajee* in February, 1857, and was found by him to be 81·74 feet, the difference being caused, in all probability, by the fall of the water between November and February, and, deducting the depths at about these

* The Sangroon Dohoo is the uppermost pool, and the Goreh the one nearest Poona. The difference of level between the top waters of these two pools was at the same time found to be 26·13 feet,—a considerable fall in so short a distance.

Mr. Gerrard's.	
94·59	
17·75	Depth measured by Major Kilner.
76·84	

Venaik's.	
81·74	
10·50	Depth measured by Venaik.
71·24	

periods, would make the bottom of the Sangroon Dohoo (the uppermost) 76·84 feet higher than the top of the Jamsetjee Bund as levelled by Mr. Gerrard, C.E., and 71·24 feet as levelled by Surveyor and Builder Venaik Bhickajee. Mr. Gerrard, C.E., made no measurement of the depth when he took the levels in November 1855. I have therefore assumed the depth to be that taken by Major Kilner in October and November, 1851, which will account for the difference in the two sets of levels, both of which were taken from the top waters, and which, of course, are constantly fluctuating. Again, in measuring the greatest depth of such an extensive sheet of water as the Sangroon Dohoo, differences must unavoidably occur; however, I think that these levels, taken by different individuals at different times, are sufficiently near for all the practical purposes of determining if water can or cannot be delivered in the Camp of Poona by gravitation from these natural pools in the bed of the Mootta River. I will, therefore, take the mean of the two sets of levels $\frac{76\cdot84 + 71\cdot24}{2}$, and consider the bottom of the Sangroon Dohoo to be 74·04 feet above the top of the Jamsetjee Bund, about the centre of it.

30. From careful levels* taken between fixed points in the Camp of Poona, and the top of the Jamsetjee Bund, the bottom of the Sangroon Dohoo above the same point, viz. 74 feet, is found to correspond with points in the Camp of Poona, as follows:—

Corner of His Excellency the Commander in Chief's compound; exactly.

The Sapper and Miner Lines; the point is two feet lower.

Front of the Ghorepoorie Barracks; all of which are situated in the lower parts of the Cantonments. Points in the new Wanowree Barracks are 164·9 feet and 176 feet above the top of the Jamsetjee Bund, and in the Horse Artillery Lines 169 and 152 feet above the same point. I trust that these levels sufficiently prove that water cannot be delivered from these Dohoos to all parts of the Poona Camp

* I am indebted to the kindness of Mr. Coke (in charge of the Engineer School) and his pupils, for this assistance.

by gravitation. There is no necessity to remark on the immense distance they are off, some sixteen miles, when other sources are comparatively close at hand.

Mr. Gerrard's (C.E.) scheme for damming up the Ambeygaum Valley.

31. This valley is situated about five miles south-west of the City of Poona, across the mouth of which Mr. Gerrard proposes to throw an earthen embankment, leading the water from the reservoir so formed, by a deep cutting with a considerable fall, across the small plateau between the Kartriz and Ambeygaum valleys, and continuing the conduit, following the sinuosities of the hills to a distributing reservoir in rear of the Hospital, old Wanowree Barracks, from which reservoir a system of earthenware piping, set in grout, is to convey the water to a number of open tanks situated in different parts of the Camp. This latter was, I believe, altered by Colonel Scott, the Superintending Engineer Central Province, to iron piping.

32. The quantity of water thus impounded, Mr. Gerrard calculates, will, making ample allowance for evaporation, amount to 57,192,400 cubic feet, or 357,452,000 gallons, which would give daily throughout the year at the rate of 979,323 gallons; more, by 179,323 gallons, than I have assumed the requirements to be.

33. I have now, I believe, noticed all the various schemes for supplying the Camp with water. I have most carefully gone over every one of the works, and examined them many times; I have also examined carefully the neighbourhood of Poona for other sites. I have nothing new to suggest, as every available situation is more or less occupied; and I have no hesitation in pronouncing that I consider Mr. Gerrard's scheme best adapted to present requirements. As far as I can see, it does not interfere with any real or supposed rights on the part of the municipality of Poona, or of individuals. The gathering ground is good and ample; there are no engineering difficulties whatever in the works; and the valley possesses all the requisites for an impounding reservoir, in a most favourable degree: and as Mr. Gerrard's designs for the details of this project have been noticed as objectionable by the Chief Engineer of Public Works (Chief Engineer of Public Works' letter to Government, No. 10211 of 1856, dated 20th December) in several particulars, having selected it as the most promising of the various schemes submitted, I now proceed to mature

it, keeping in view the Chief Engineer's remarks above alluded to. At the same time, I will not mislead Government by allowing them to suppose that it can be carried out for a small outlay. Supplying forty thousand people with pure drinking water from a distance of six or seven miles, and delivering it at convenient situations over a large and extensive Camp, besides providing storage room for a head of water to flush sewers and drains, in addition to the main reservoir, cannot be carried out for a small amount.

A general explanation of the scheme submitted by Captain Hart.

34. The general explanation of the scheme now submitted is as follows:—The construction of an earthen dam across the gorge of the valley near the village of Upper Ambeygaum, 1,270¼ feet in length, its greatest height above the bed of the stream being 59·86 feet. From the reservoir so formed, the water will be led by either an iron conduit pipe or masonry aqueduct, whichever may be the most economical, to the most favourable point for crossing the small plateau of the spur dividing the Kartriz and Ambeygaum valleys. Through this portion a tunnel will be driven 2,781½ feet long, opening at the head of the Duncowree Valley. The course then for either pipe or aqueduct will be down this little valley for some short distance. If by pipe, it will run almost straight to a distributing reservoir to hold one or two days' supply, near the solitary cells in the Camp of Poona; and if by an aqueduct, before reaching the mouth of Duncowree Valley, it will branch off, running slightly up the Kartriz Valley, crossing the Kartriz aqueduct, round under the village of Beebee Warree, and thence following the sinuosities of the hills to the distributing reservoir above mentioned. If by a masonry aqueduct, the length will be 7m. 6fur. 65⅗yds.; or, by an iron pipe, it will be 5m. 1fur. 94⅓yds., the total fall from the bottom of the reservoir being 80·25 feet. The distributing reservoir, as above observed, will either contain one or two days' supply, and from it the water will be conveyed to every part of the Camp by iron pipes, with a stand-pipe at each cistern. The situation of the cisterns, their number and capacity, will correspond with the wants of the neighbourhood in which they are located.

Plans accompanying the Report.

35. The following Plans accompany this Report. All have been surveyed and prepared afresh, without the slightest reference to those submitted by Mr.

Gerrard, C.E., which, from their description, I imagine were intended to be of an entirely preliminary nature.

No. 1.—Trigonometrical survey of the Ambeygaum valley, and country between it and Poona.

No. 2.—Plan of the embankment, with longitudinal and transverse sections, &c. &c.

No. 3.—Contoured Plan of the reservoir, with site of the waste weir and cut, &c. The contours being taken at every four feet of vertical distance.

No. 4.—Plan, elevation, and section of the gangway, with details, &c.

No. 5.—Plan, elevation, and section of the inlet tower.

No. 6.—Various details, with a plan and section of a two days' distributing reservoir.

No. 7.—Various details, with a plan and section of a one day's distributing reservoir.

No. 8.—Plan and longitudinal sections of the whole course of an iron pipe and masonry aqueduct, with details, &c.

No. 9.—Plan of the Cantonment and Lines at Poona, showing the proposed distribution throughout the Camp.

Brief description of the Ambeygaum Valley.

36. The valley of Ambeygaum is situated about five miles south-west of Poona, being one of those formed by the spurs which run out from the Singhur range of hills. Its southern limit is very lofty, being the main range itself, while on the east and west sides well-defined and lofty spurs run out. The general configuration of the valley possesses, I am of opinion, every requisite as a drainage area for collecting water. It is particularly deep and precipitous at its upper end, and flanked by lofty hills. At its lower end, near the village of Upper Ambeygaum, the mouth contracts, and it is at this point I propose constructing the earthen dam. I believe it to be the very identical spot, or very nearly so, selected by Mr. Gerrard. Excellent material for its construction abounds on the spot.

Requirements of the Poona Cantonment, as to the supply of water.

37. In paragraphs 10 and 11, and from the letter in the Appendix marked A, which was framed with much care, it is stated that the population of the Camp and Bazar, including Horse Artillery, horses, &c., amounts to 37,682, which, in

round numbers, may be assumed at 40,000, and with the allowance of twenty gallons per head daily, the minimum allowed for in England, 292,000,000 gallons will be the annual requirement; but, to allow a safe margin, for the reasons stated in the concluding part of this paragraph, 300,000,000 gallons per annum may be assumed as the quantity required.

	Gallons.	Cubic Feet.
Per annum, required	300,000,000	48,154,093
,, day, ,, ...	821,917	131,929
,, hour, ,, ...	34,246	5,497
,, minute, ,, ...	570·77	91·61
,, second, ,, ...	9·51	1·52

Ample allowance having, I think, been made in the calculation, for the remaining purposes of waste, leakage, flushing sewers, watering camp roads or public trees, and especially for future requirements to the Railway terminus, and extension to the Civil Lines, the surplus for which amounts to 24,921,400 gallons yearly, or daily to 68,277 gallons, equivalent to supplying 3,414 individuals with 20 gallons per head daily, or about nine per cent. above actual present requirements.*

38. From a most careful survey of this valley, the catchment basin, or gathering ground for the reservoir, contains an area of 4 sq. miles, 232 sq. acres, 22,680 sq. feet; or, 2,792 acres, 22,680 sq. feet.

Area of gathering ground.

39. From the Appendix marked B, containing observations of the rain-fall at Poona for the last twelve years, made at the Staff and Civil Hospitals, the average over that period is 25 inches 89 cents. The fall of rain, however, amongst the hills of the Ambeygaum Valley is, in all probability, much greater. The minimum fall extending over the same period is 14 inches 78 cents. As 640 acres equal a square mile, and one acre is equal to 43,560 sq. feet, a fall of one inch of rain is equal to 3,630 cubic feet per acre, and $3{,}630 \times 640 = 2{,}323{,}200$ cubic feet

Calculations of the rain-fall.

* It was partly with a view of providing at any time an increased supply that the pipe and aqueduct were led down the Duncowree Valley. Cuts in this valley, connected with the main conduit, would, I am of opinion, furnish a large additional supply at any time.

per square mile. Therefore a fall of twenty-five inches will be 58,080,000 cubic feet per square mile; and for four square miles 232,320,000 cubic feet, or 1,447,353,600 gallons. With the minimum fall of fourteen inches for four square miles, the amount will be 130,099,200 cubic feet, or 810,518,016 gallons, of which only 6-10ths may be considered available for the supply of the reservoir; making, with the average fall of twenty-five inches, 868,412,160 gallons, and with the minimum fall of fourteen inches, 486,310,809 gallons;—in the first case, the supply being nearly three times as much as is actually required; and with the minimum fall, one and a half times more. I have assumed 6-10ths of the rain-fall as the available supply for the reservoir, as being the quantity usually allowed for, I believe, in England.

40. Attached to this Report, in the Appendix lettered C, is a return of the water gauged at the Great Kondwah Nullah, the back of the Upper Kartriz Tank, and the Ambeygaum Nullah, from the 24th February to the 8th June. 1857; the general result of which is as follows:—

Result of gauging, during the last hot season, the Great Kondwah Nullah, the back of the Upper Kartriz Tank, and the Ambeygaum Nullah.

			Gallons.	
The Great Kondwah Nullah supply was		..	1481	per hour.
The Upper Kartriz Tank	do.	..	300	„
The Ambeygaum Nullah	do.	..	1179	„

A sufficient approximation, I think, that the first and last, affording such a supply during the hot season, are amply sufficient for supplying the Camp, while several heavy floods passed down these streams and were lost; and as regards the Upper Kartriz Tank, sufficient dependence is not to be placed on it, in its present condition, as a means of supply.*

41. Having shown that the gathering ground is more than ample for the supply of the estimated requirements, I proceed to notice the storage capacity of the reservoir. The following Table shows the contents of different heights, the contours having been taken at 4 feet vertical distance apart:—

Storage capacity of the proposed reservoir.

* At this time, 3rd August, 1857, the tank is nearly dry.

Depth of Reservoir.	Area in Acres and Square Yards.		Cubic Feet.	Gallons.
Feet.	Acres.	Sq. Yds.		
4	4	2593	790,316	4,923,668
8	8	1041	2,221,714	13,841,278
12	13	2436	4,574,554	28,499,471
16	17	4670	7,704,774	48,000,742
20	23	4246	11,865,170	73,920,009
24	28	2732	16,842,272	104,927,354
28	34	952	22,800,728	142,048,535
32	40	1370	29,819,666	185,776,519
36	45	2798	37,761,220	235,252,400
40	51	864	46,678,598	290,807,665
44	63	3028	57,764,750	359,874,392
48	77	2979	71,288,504	444,127,387

So that, with the dam at the 40-feet high contour, the reservoir will contain 290,807,665 gallons, sufficiently near the requirements assumed, of 300,000,000 gallons, for all practical purposes.

Evaporation. Col. Scott's letter, No. 605 of 1856, to the Assistant to the Chief Engineer of Public Works, dated 7th February.

42. Colonel Scott, the Superintending Engineer of the Central Province, from experiments made on different tanks, states that half an inch per day would be an ample allowance to make. This quantity during the eight dry months would amount to 10 feet annually. In assuming, therefore, in the Deccan the evaporation at eight feet, I think a safe allowance has been made, as at least two feet may be deducted from Colonel Scott's experiments for casual showers at the commencement of the cold and towards the close of the hot season. The supply therefore of the reservoir, at 48 feet, is 444,127,387 gallons, which is the proposed top water; 4 feet above that again being taken for the top of the embankment; and the bed of the Nullah below the level of the first contour being 7·86 feet, will make the total height of the embankment, in its highest part, that is, from the bottom of the bed of the stream to the top of the dam, 59·86 feet.

43. I will now proceed to give a description of the principal works required, in the following order: –

1. Embankment.
2. Waste weir.
3. Cut to carry off first floods.

4. Inlet tower and filter.
5. Gangway.
6. Aqueduct, pipe, and tunnel.
7. Distribution reservoirs.
8. Camp distribution.

44. The following are the dimensions of some of the principal embankments for impounding reservoirs in England and America:—

1.—*Embankment.*

Names of Works.	Height above top of Water.	Width of Embankment at top.	Inside Slope.	Outside Slope.	Remarks.
Longdendale Reservoir ..	4	27	3 to 1	2 to 1	
Crowden do. ..	4	15	3 to 1	2 to 1	* With a berm 5 feet wide on the inside slope; the remainder of the slope 3 to 1.
Albany Works	8	10	2 to 1*	2 to 1	
Brooklyn do.	5	20	3 to 1	2 to 1	

I have therefore adopted the breadth of the dam at top to be 20 feet, inside slope 3 to 1, and outside 2 to 1; with a puddle-wall of clay in the centre of the dam 8 feet wide at top, increasing in width at the rate of 4 feet for every 10 feet of depth; and the top of the dam to be 4 feet above the top water. Careful excavations were made along the line of the intended embankment, the bottom of which is shown by the dotted line coloured yellow in the longitudinal section in Plan No. 2, which line denotes the probable bottom of the puddle trench along the whole length. At the foot of the embankment on the upstream side, a small dwarf wall of rubble masonry will be built, for the pitching which protects the inner slope to abut against. The embankment will be formed in regular layers, well watered and rammed, sloping inwards from both faces. Some slight difficulty may be apprehended in draining the trench in its deepest part, to receive the puddle, but excellent material exists on the spot for the formation of both puddle and embankment. The length of the dam will be 1,270¼ feet, its greatest height 59·86 feet, the reservoir having an area of 77 acres 2,979 square yards.

45. From a careful observation of most of the remains of tanks which I have seen in this country,—I, of course, allude to those formed by earthen mounds, including the ruins of many in the Nundoorbar Talooka of the Kandeish Collectorate,—the embankments almost invariably appear to have failed from having either no waste weir at all, or one of very limited dimensions. The reason of the failure of the embankment of the Kussoordee Tank arose, I believe, entirely from this cause. It is very clear that a sufficient outlet for the rapid escape of heavy floods in works of this nature, in a country where they are occasionally so sudden, is obviously necessary. It will scarcely be credited with what rapidity and suddenness these mountain streams fill, but by those who have actually witnessed it. In May last, the surveyor was surveying the upper portion of the Ambeygaum Valley, and had only just time to remove the chain and field compass out of the Nullah, when it came down, warning having been given in time by a cultivator at work in his fields at some distance higher up the valley. When the flood came down, the man described it like a wall of rolling water, and I can affirm the description to be perfectly true. I feel, therefore, on the above accounts, to be strongly impressed with the absolute necessity of providing an ample outlet for the surplus water, altogether independent of the artificial cut shown in Plan No. 3, which will be hereafter noticed. From an inspection of this drawing, it will be seen that the ground is favourably situated for the construction of the waste weir round the eastern end of the embankment. I have, accordingly, provided for a width of 100 feet, the channel being 841 feet long. With a depth of water of one foot over this channel, the fall of water, according to a formula of De Buat, would be per hour 7,516,968 gallons.

2.—Waste Weir.

46. There is scarcely a work in the Deccan, whether a dam across a river, or an embankment to dam up a stream, wherever, in fact, running water is opposed to any extent, that silting-up does not follow as a matter of course, and of time only as to its extent. This can be retarded in some degree, by the adoption of such a form of dam that the silting it up may be locally regulated; or by openings in the dam, through which, to a certain extent, it can be got rid of; but no practical means that I have yet seen can wholly prevent it. For instance, supposing,

3.—Cut to carry off first floods.

instead of the earthen mound for the work, that a masonry dam was substituted, and the masonry was perforated everywhere with openings for sluices, the silting-up still takes place at the sides of the reservoir and in the spaces between the openings, for there must be some portion of dead wall in the dam. We have, in fact, practical examples before our eyes everywhere, of works of this nature filling up with deposit.

47. In all tanks formed by damming up running streams,—and the same cause is operating with respect to rivers, take the Khandeish river dams, for instance,—the filling up is doubtless caused by the first heavy floods of the monsoon rains, bringing down with them in suspension portions of the surfaces of the arid hills. This silting-up is in progress, more or less, in every situation under similar circumstances; yet, in moister climates, where vegetation prevails, the progress is of course not so rapid as in dry ones, where, for eight months of the year, the burning sun of a cloudless sky has full play on the parched-up soils. This being immediately succeeded by heavy tropical rains, portions of the surfaces of the hills are annually washed off, and the detrition deposited wherever the course of the running water is obstructed.

48. Whatever advantages may be attached to the sluices formed in a masonry dam, by keeping them open and allowing the first floods of the monsoon to pass through, to disturb the consistency of an extensive earthen mound by any perforations of this nature, however strongly such may be protected, would, in my opinion, be extremely unadvisable.

49. To prevent therefore, as much as possible, the detritus from the hills being brought down during the first heavy floods of the monsoon, and deposited in the reservoir, I propose to divert the feeding channel by an artificial cut, with strong masonry walls across the main and minor streams. This cut will pass round the eastern end of the embankment, as shown in Plan No. 3. Openings will be left in these cross walls, with planks to lift up and down, through which the clear water may be permitted to enter the tank, when the first heavy, muddy floods have passed off. The Lower Kartriz tank is provided with a channel of this description, and it is in all probability owing to this that the tank has not as yet wholly filled up. In such an artificial channel as that recommended, it is particularly desirable that the masonry works across the main and minor streams should

be of strong section, and not likely to fail; or the opening caused by the failure of one wall would allow so much of the deposit to fill the tank as could in all probability never be wholly removed, even supposing sluices were provided; and where there are none, it would remain, and never be got rid of at all.

50. My idea is, although no provision has been made in the estimate for it, as I am afraid it will already amount to much more than was originally contemplated, that four or five capacious wells (those already existing, if repaired, would answer probably), domed over, should be sunk in the lowest portions of the reservoir, each well connected by a masonry duct, or pipe, with a proper fall; certain portions being built dry, with apertures sufficient to admit of the leakage of the water through, but of so small a size as to exclude the formation of deposit in them. These ducts or pipes, being connected with each other, should communicate with the bottom of the inlet tower, and whether the reservoir silted up or not, they would always afford a constant supply of water.* No evaporation could take place, as they would in time be probably covered with the deposit, this *débris* holding in suspension vast quantities of water, which would find its way to a lower level into these covered wells, and thence, by the inlet tower, to the conduit pipe or aqueduct. Supposing such to have been built at the period the Upper Kartriz dam was constructed, they would now be the sources of a vast and constant supply from the *débris* itself. I never heard of wells failing in the bed of a dry tank, nor have I ever known them even running dry when in the vicinity of such a water-bearing medium.

51. The total length of the cut will be 7,900 feet, with a general section similar to that of the present Nullah; width at bottom 40 feet, with the banks properly sloped.

4. —*Inlet Tower and Filter.*

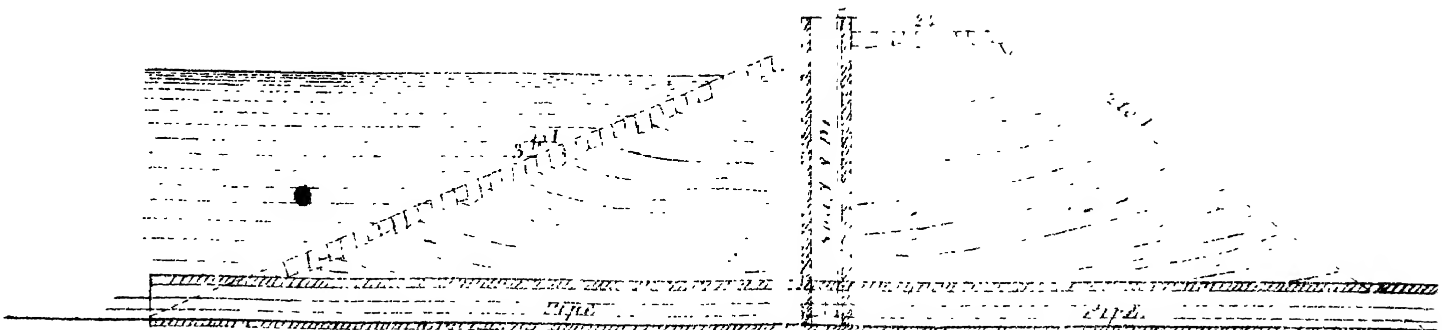
52. The inlet tower is the means by which the water from the reservoir is filtered, and the supply regulated to the conduit pipe or aqueduct. In tanks

* There is a large well of this sort in the bed of the Lower Kartriz tank, at its western end near the dam, connected with the aqueduct through the dam wall. On this well, and the water stored in different reaches of the aqueduct itself, is the City dependent for the supply in the middle and at the end of the hot weather. Doubtless the deposit, holding vast quantities of water in suspension, is the source from which the well is supplied; and it is not at all improbable that it covers a spring, which was in existence before the dam was built.

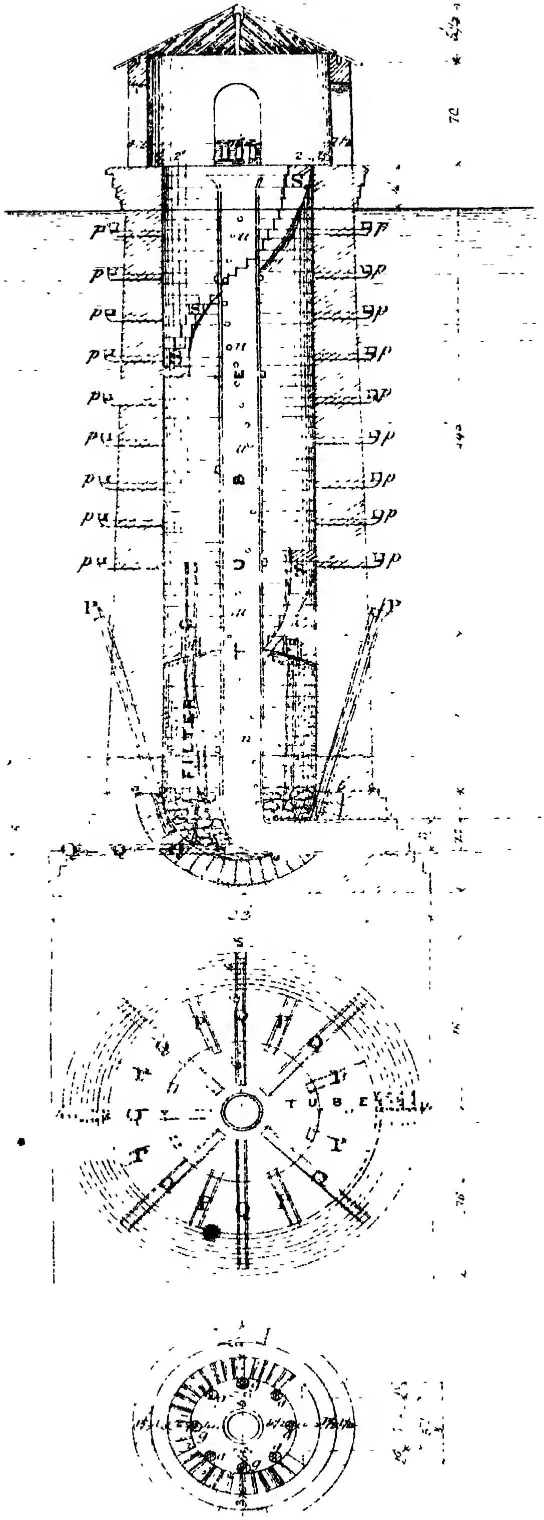
in the Deccan formed with masonry dams, the same principle is not unfrequently observed. A square tower is built in front of the Bund wall, with steps down it, or more commonly holes left in the sides to receive the feet when ascending or descending. The water from the tank is let into the tower by orifices in the wall furnished with plugs, and from thence the supply is regulated to the aqueduct. In some of the works in England an inlet tower of the description proposed is used, while in others (in the Manchester Water-works, I think) there is no tower, but a brick shaft communicates with a culvert running through the embankment in which the supply-pipes are laid. Rods pass up this shaft communicating with the valves in the pipes, and the supply is regulated from the top of the dam. The annexed Diagram will show what I mean.

I have, however, for the reason before explained, a strong objection to interfere with the earthen mound, beyond what is absolutely necessary, or cannot be avoided; I have therefore placed the inlet tower at the foot of the embankment, in the deepest part of the reservoir, in order to obtain the water from the reservoir when at its least possible level. The bottom of the pipe, or aqueduct, has been taken nine feet below the bed of the stream.

53. In order better to explain the use and purposes of this work, I attach a Diagram, to which reference is requested in the following account of it. In the foundation of the work, seven cuts (Q, Q, Q, Q, Q, Q, Q) are left filled up with dry stone, radiating from the centre of the tower, through which any springs or drainage can enter at the base of the filter, or water percolate through from the reservoir itself. At a height of 15 feet above the footings of the foundations, iron pipes (P, P, P), eight in number, are built into the walls of the tower, passing obliquely through them. They are placed in the intermediate spaces between the cuts above mentioned (Q, Q, Q). The water from the reservoir enters the pipes (P, P, P) and the cuts (Q, Q, Q) at the bottom of the filter. From this it will be seen that the base of the tower is intended to act as a filter; it is 13 feet in diameter and 23 feet in depth. At the point where the mouths of the pipes (P, P, P) are built into the tower, that is, 15 feet from the footings, the filter is domed over with a stone floor, in which the iron gratings (*g*, *g*, *g*) are built, and screwed down to the stone floor. The water therefore can only enter the tower at the bottom of it, and passes



Culvert Tunnel Oct 1854


FILTER
TUBE

through the filter by the gratings into the body of it, to obtain the same level as the water in the reservoir outside the tower.

In the interior of the tower, between the top and the domed stone floor (G, G), a staircase of stone (S, S) runs spirally round the inside of the tower. Down the centre of it, extending from the top to the base, an iron cylinder or tube runs, in direct communication with the pipe or aqueduct which it joins. This tube is altogether independent of the tower; it rests on the base of it, and may probably require ties in one or two places to keep it steady, passing through the outer walls of the tower; it passes through the floor (G) to the very base of the tower. This tube is provided with tubular orifices and plugs at every two feet of vertical height, running spirally round it, corresponding with the steps, or the man descending would not be able to reach the plugs for the purpose of opening and closing them. The water then from the reservoir enters the very bottom of the tower, ascending through the filter into the upper part, to the same level as the water outside, and is let off into the tube through the tubular orifices, by opening or closing the plugs (*u*, *u*, *u*, *u*, *u*). The tube is proposed to be three feet in diameter, more than its actual requirements as regards the water passing down it, to enable a man or boy to be let down at any time to refix or overhaul the plugs. My object in the adoption of the tube was the avoidance of all sluices, the management of which natives do not comprehend and cannot repair. Plugs answer the present object equally well, and, what is better still, any native understands their object and use. These plugs (*u*, *u*, *u*, *u*) have been carried to the very bottom of the filter almost, to take advantage, in seasons of peculiar drought, of every drop of available water. In cases of emergency, I have also provided for tubular orifices (*p*, *p*, *p*, *p*), to communicate direct with the reservoir, and through which unfiltered water can be let into the tube when required. The discharge through these tubular orifices (*p*, *p*, or *u*, *u*) would be, at depths of 2, 4, and 6 feet respectively, 1·80, 2·55, and 3·12 cubic feet of water per second. See Appendix, lettered D.

54. There may be some objection raised, and with reason too, of the difficulty of clearing out and renewing such a filter; it will, however, last some years; and in seasons of drought, at the close of the hot weather, when the water in the tank is low, the sand might

be partially removed and renewed. Supposing even that it does not completely answer its purpose, of which I have no doubt,—it is the difficulty of renewing it which I consider objectionable,—but little extra cost has been incurred; it is, after all, only the filling in with sand, &c. The construction of a filter is a work that can be executed at any time hereafter; and supposing the masonry aqueduct to be adopted, I doubt whether the attrition of the water against its sides will not be sufficient, and that a filter will be required at all; at any rate, it is a portion of the work which I do not feel inclined, at present, to incur any expense in undertaking.

5.—Gangway.

55. The gangway is the passage across from the embankment to the inlet tower. It is formed of two trusses, on Horne's patent principle; one of the simplest description of wooden bridge yet invented, and at present much adopted, both in Canada West and in the United States, for road and railroad bridges. The total length of the gangway is 180 feet. with a clear breadth of passage of $5\frac{1}{2}$ feet, supported at one end by the inlet tower, at the other by a pier built in the embankment, and in the centre by a high pier; this gives two clear spaces of $84\frac{1}{2}$ feet each, the pier in the centre being 4 feet thick at top. The trusses are composed of top and bottom chords, with diagonal bracing between the lower chords. Between the upper and lower timbers of each truss there are main and counter braces, abutting on cast-iron brace-blocks, with iron suspension rods between. The planking is $3\frac{1}{2}$ inches thick, laid across the two trusses; there are no joists.

6.—Iron pipe Aqueduct and Tunnel.

56. In order to compare the cost of conveying the water from the main to the distribution reservoir in the Camp, Plan No. 8 contains longitudinal sections for both an iron pipe and masonry aqueduct. The total length of the former is 27,343 feet = 5 m. 1 fur. $94\frac{1}{3}$ yds.; of the latter, 41,116 feet = 7 m. 6 fur. $65\frac{1}{3}$ yds., the pipe being shorter than the aqueduct by 2 m. 4 fur. 191 yds., the measurements commencing from the starting point of either, the centre of the inlet tower, and ending at the Camp distribution reservoir, marked A in Plans Nos. 1 and 8. The course of both is the same for a distance of 11,478 feet = 2 m. 1 fur. 86 yds., from the main reservoir to the middle of the Duncowree Valley; the iron pipe from this point taking an almost direct course towards the Camp, while the aqueduct neces-

sarily follows the sinuosities of the hills, to avoid the heavy work which a more direct course would entail, and which does not in the same manner affect the line of the pipe.

Description of the course of the iron pipe.

57. I will now describe the course of each of these modes of conveyance separately, commencing with the iron pipe. As before observed, the pipe and aqueduct maintain the same line for a distance of 11,478 feet = 2 m. 1 fur. 86 yds.; from the centre of the inlet tower, 9 feet below the bed of the Nullah, it runs with a slope of a quarter of an inch to 100 feet, for a length of 4,729½ feet, to the head of the little plateau dividing the Kartriz and Ambeygaum valleys. At this point the tunnel commences, along which the pipe is laid, from the bottom of a masonry shaft 4 feet square, sunk 61 feet below the surface of the ground. From this last shaft the pipe is laid for a distance of 2,570 feet, at an inclination of 0·84 foot to 100 feet, to a chambered shaft, constructed over a very promising spring (No. 3, Plan No. 8), and sunk 21 feet below the surface of the ground. This shaft is divided into two compartments, the water from the pipe being discharged into one, and let off into the other by means of plugs in the division wall. From the base of the shaft No. 3 the pipe leaves, for a distance of 3,255½ feet, at a slope of 1·59 to 100 feet; and for another 594 feet, at a slope of 3·72 to 100 feet; it then rises and falls at various inclinations noted on the Plan for the remainder of its length, a distance of 13,422·5 feet, until it reaches the Camp distribution reservoir. The head of water from the bottom of the shaft No. 3 (in Plan No. 8) is 31·5 feet, which is considered ample to overcome the different rises in its length. There is no necessity, in the whole length of the pipe, for any aqueducts or other works, beyond the mere trench in which it is laid.

Description of the course of the masonry aqueduct.

58. The masonry aqueduct leaves the centre of the inlet tower at ·9 feet below the bed of the Nullah, being connected with the iron tube by means of a masonry chamber, and runs with an inclination of a quarter of an inch to 100 feet for a distance of 4,729½ feet, to the entrance of the tunnel, which leaves the bottom of a masonry shaft 4 feet square, sunk 61 feet below the surface. It then proceeds along the tunnel level, for a distance of 2,781½ feet, to a similar masonry shaft, sunk 65¾ feet, at the head of the Duncowree Valley.

On quitting the tunnel it proceeds with an inclination of 0·84 foot to 100 feet for a distance of 2,570 feet. This portion is divided into two falls by two chambered shafts (Plan No. 8, Nos. 3 and 4), respectively 21 and 31 feet deep below the surface. The water is received into one compartment of the shaft, and discharged into the other by means of plugs in the division wall (see details in Plan No. 7). No. 3 shaft is that covering the spring, allusion to which was before made in the description of the line of iron pipe. It then again falls with an inclination of 1·81 feet to 100, for a further length of 1,397 feet, the distance being divided into two falls by chambered shafts Nos. 1 and 2 (Plan 8, details Plan 7), sunk respectively 11 and $19\frac{3}{4}$ feet below the surface of the ground. From the last shaft (No. 1) to the camp distribution reservoir is a distance of 29,638 feet, over which the aqueduct is carried at a uniform slope of a quarter of an inch to 100 feet, being provided with air-shafts at every 500 feet. Throughout this last portion of its length, the only work which will be required is, raising it about 6 feet high to a length of above 1,200 feet, over a hollow portion of ground not far from the Camp distribution reservoir.

The section of the aqueduct varies in some places.

59. The section of the aqueduct is the same throughout, except for that portion between shafts Nos. 1 and 5, a distance of 3,967 feet, which, owing to the unavoidable slope, it has been considered advisable to make of a longer and stronger section; and for the portion passing under the embankment, the head is arched instead of flat. The tunnel along which the water runs, being a distance of $2{,}781\frac{1}{2}$ feet, is also of a different section. The details of all which are plainly shown in Plan No. 7.

Diameter of the pipe.

60. The Appendix, lettered D, contains four different calculations for finding the diameter of the pipe, the least being calculated at 10·64, and the greatest at 13 inches. The mean of the whole is 11·5 inches, and allowing 1-6th of the diameter so calculated, to be increased to meet loss of head, apart from that of friction, which I believe to be usual in practice, would make the diameter of the pipe 13·41 inches. Thirteen inches would, I therefore think, be a safe size to allow for.

Area of the aqueduct.

61. Under the letter above referred to in the Appendix will also be found five different formulæ, with the answers attached, for the purpose of ascer-

taining the area of the aqueduct. The least side is 9·94 inches, and the greatest 13·32 inches. The mean of the five is 11 inches, or 121 square inches. I have therefore given the aqueduct an area of 270 inches, a little more than double that of the calculations, being 15 inches high by 18 inches broad, interior measurement. This, I think, will be found necessary; and were it not for the increased outlay, I should feel much inclined to make it of such a height and breadth that a boy could enter and be able to clean it out when required. This however, would considerably enhance the first outlay; constructed of the present size, when requiring to be cleaned, it must be opened out in places.

7.—Distribution Reservoirs.
Two and one day's supply.

62. The water from the pipe or masonry aqueduct, as generally described in paragraph 34, will be led to a distribution reservoir, proposed to be excavated in a vacant piece of ground in front of the solitary cells, the difference of level between which and the bed of the Ambeygaum Nullah, where the inlet tower is to be constructed, is 80·25 feet. This reservoir will contain either one or two days' supply. Plans 6 and 7 show the details of both reservoirs. The point marked A on Plans Nos. 1 and 8, or S on Plan No. 9, is almost the highest point in Cantonment, being 224·5 feet above the top of the Jamsetjee Bund; so that, from a reservoir situated on this ground, there is not an inhabited portion of the Camp which cannot be supplied with water by gravitation, besides giving a considerable head for the flushing of sewers and drains.

63. From paragraph 37 it will be seen, that one day's supply is 821,917 gallons, or 131,929 cubic feet, calculating for the supply of the reservoir in round numbers at three hundred million gallons; but, taking forty thousand as the population at twenty gallons each per day, for two days the contents of such a work would amount to 256,821 cubic feet, or for one day to 128,410 cubic feet; and, if storage room be afforded for these quantities, it will, I think, be quite sufficient. By referring to Appendix, lettered E, the dimensions of a distributing reservoir for a two days' supply will be 201 long × 130 broad × 7 deep; and for one day's supply 170 long × 130 broad × 7 deep. The larger reservoir I have divided into two parts by a central wall, in order that one may be cleaned out while the other is in use, and as always furnishing a sufficient supply for flushing sewers

and drains. In the smaller reservoir there is no division wall. In the larger the orifices and plugs which supply the two halves are quite distinct, so that either of the halves can be filled, while the other is being cleaned out. The general plan of both reservoirs is rectangular, with a high wall surrounding them. The water from the supply-pipe, or masonry aqueduct, is conveyed into the cistern C (Plans 6 and 7), and from the cistern is again discharged into the reservoir. From this reservoir it is received into another reservoir (N) on the opposite side, from which last the distribution pipes of the Camp are furnished. In the line of the steps of both cisterns, so as to be easily accessible, orifices are made in the cistern walls at one foot central distance apart, with plugs on both sides. These orifices are 6 inches in diameter, and the discharge per second, at depths of 2, 4, and 6 feet, will be 1·38, 1·95, and 2·39 cubic feet respectively. (See Appendix, lettered D.)

64. From the distribution reservoir above described, a series of iron pipes will convey the water to the different parts of the Cantonment, with an iron stand-pipe and stop-cock at each cistern; the pipes being always charged with water. The cisterns are so placed as to be most conveniently situated for the neighbourhood they are intended to supply; but for each hospital (except the Staff hospital, which is between the cistern and the N. I. Regiment Hospital, and Sapper and Miner Lines) one of the smaller description of cisterns 15 broad × 10 long × 8 deep, containing 1,200 gallons, is placed in the compound. There are three principal branches of pipes, one for supplying the Horse Artillery Lines, one for the New Wanowree Barracks, Native Infantry Regiments, and Ghoreporee Barracks, and another for the supply of the Bazar, Commissariat, Sappers and Miners, and Officers' Lines. A branch also runs to the Malcolm Tank in the Bazar, which is the only reservoir in a fit state ready at hand, that I have been able to avail myself of, to fill from the distribution reservoir.

8.—*Camp Distribution.*

65. By a reference to the Appendix, lettered F, it will be seen that the numbers and capacities of the cisterns have been apportioned, as nearly as practicable, to the wants of each locality. In all, thirty-six cisterns will be required, twenty-four of the larger sort, 25 × 18 × 8 feet, and of the smaller twelve, 15 × 10 × 8 feet, each containing 2,000 and 1,200 cubic feet respectively. The capa-

cities of these cisterns, with that of the Malcolm Tank, give 1,21,666 cubic feet, which is sufficiently near to the quantity required for all practical purposes. The cisterns are supposed to be filled daily from the hydrant which is attached to each, or oftener, if necessary, by one of a regular establishment in whose charge the works will remain.

66. The total length of the pipes required for the Camp distribution is entered in the Appendix, lettered G, and amounts to 8 miles, 1,643 yards, 2 feet, the first half of which should be 5-inch, and the latter half 4-inch pipes. Plan No. 9 shows the proposed distribution in detail, in which are entered the various heights of the different localities above the Jamsetjee Bund.

67. The amounts of the estimates of the various works for supplying the Camp of Poona with water, from the Ambeygaum Valley, are as follows:—

	Rupees.
The embankment	1,52,064
The waste weir	10,517
The artificial cut to carry off the first floods	24,651
The inlet tower	12,172
The gangway	9,082
The masonry aqueduct and tunnel	1,14,969
The 13-inch iron conduit pipe and tunnel	1,85,434
The distribution reservoir, to contain a two days' supply	36,834
The distribution reservoir, to contain one day's supply	22,599
The Camp distribution	1,03,409

Of which I would beg to recommend the following for adoption, as follows:—

	Rupees.
The embankment	1,52,064
The waste weir	10,517
The artificial cut to carry off the first floods	24,651
The inlet tower	12,172
The gangway	9,082
The masonry aqueduct and tunnel	1,14,969

	Rupees.
The distribution reservoir, to contain one day's supply	22,599
The Camp distribution	1,03,409
Total. ..	4,49,463

Amounting to Rupees four lacs, forty-nine thousand, four hundred and sixty-three.

68. The Establishment, as per margin, was placed at my disposal by the Chief Engineer of Public Works for the surveys and sections required for this project, and I have much pleasure in acknowledging the valuable assistance which I have received from Surveyor and Builder, Venaik Bhickajee.

Surveyor and Builder, Venaik Bhickajee.
Sub-Assistant Surveyor and Builder, J. Wainwright.
Probationer Sub-Assistant Surveyor and Builder, Muncherjee Cowasjee.

(Signed) Philip L. Hart,
Captain Engineers, on Special Duty.

Poona, 23rd October, 1857.

APPENDIX.

A.

No. 515 of 1857.

From the Acting Deputy Assist. Quarter Master General, P.D.A.
To Captain P. L. Hart, Engineers, on Special Duty, Poona.

Acting Deputy Assist. Quarter Master General's Office, P.D.A.
Poona, 24th February, 1857.

Sir,—In acknowledging the receipt of your letters Nos. 12 and 19, dated the 17th and 23rd instant respectively, I have the honour to annex, for your information, an estimate of the whole population of the Cantonment of Poona, supposing it to be fully garrisoned, as follows:—

CORPS AND DEPARTMENTS.	Number of Population.	Number of Cattle.
Artillery, two Troops of Horse Artillery, and European Company of Artillery with Light Field Battery ..	4,674	680
Head Quarters Sappers and Miners; three Companies.	1,363	64
Two European Infantry Regiments	4,880	298
Two Native Infantry Regiments ..	4,634	278
Ordnance Department	515	32
Bazar, Commissariat Department, Pensioners, &c.	17,828	1,686
Staff; civilians and others unconnected with Regiments, non-residents	600	150
Total....	34,494	3,188

Population 34,494
Cattle 3,188

Total.... 37,682

2. Great care has been taken in framing this Return, and it is believed it will prove correct in all particulars.

I have, &c.,

(Signed) J. C. Coley, Captain,
Acting Deputy Assist. Quarter Master General, P.D.A.

(True copy)

Philip L. Hart,
Captain Engineers, on Special Duty.

B.

Fall of Rain in Poona, for the last Twelve Years, extending from the Year 1845 to the Year 1856, gauged at the Staff and Civil Hospitals.

	1845.		1846.		1847.		1848.		1849.		1850.		1851.		1852.		1853.		1854.		1855.		1856.	
	In.	Cents	In.	Cents	In.	Cents	In.	Cents	In.	Cents	In.	Cents	In.	Cents	In.	Cents	In.	Cents	In.	Cents	In.	Cents	In.	Cents
January	..	..	..	..	..	..	..	..	..	28½	..	..	..	..	..	..	..	..	..	..	..	..	..	..
February	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..
March	..	..	..	..	..	24	..	..	..	..	..	..	..	..	..	34	..	..	.	..	..	89	..	..
April	..	..	..	..	4	4½	..	..	..	.	..	66½	..	.	..	.	..	..	..	55½	1	33	..	25
May	2	21	1	27½	2	51	2	78	..	40½	..	..	..	55	2	18	2	27	1	58	..	28	2	36
June	3	12	8	78½	2	78½	1	30½	7	95½	3	39	4	48	7	44	16	22	..	51	5	28	1	38
July	1	11	5	85	2	71	4	16½	6	42½	8	15½	9	18	6	46	14	22	8	92	9	46	8	46
August	1	66½	1	9½	2	11	1	..	10	3	1	1½	4	61	8	14	4	5	1	70	1	73½	2	76
September	5	54½	1	46	..	..	1	90	4	42½	..	42	1	1	5	12	1	20	9	91	3	54	2	80
October	1	13	4	73	..	87½	2	13	2	46	5	55	..	9	2	70	..	..	8	96	12	3	1	42
November	..	..	1	92	5	9	2	24	1	79½	..	14	2	24	..	..	..	..	1	97	..	..	..	44
December	..	..	..	23	..	..	..	..	..	..	..	14	..	..	..	.	..	..	..	..	..	..	..	..
Total	14	78	25	34½	20	73½	15	52	33	78	19	47½	22	19	32	38	37	98	34	10½	34	54½	19	87

(True Copy)
(Signed) PHILIP L. HART,
Captain Engineers, on Special Duty.

(Signed) T. B. LARKINS,
Staff Surgeon.

(Signed) J. KEITH,
Civil Surgeon.

Abstract of Twelve Years' Rain-fall at Poona, from 1845 *to* 1856.

	Inches.	Cents.
1845..	14	78
1846..	25	34½
1847..	20	73½
1848..	15	52
1849..	33	78
1850..	19	47½
1851..	22	19
1852..	32	38
1853..	37	98
1854..	34	10½
1855..	34	54½
1856..	19	87
Total....	310	70½

The average rain-fall of twelve years is................25·89
Least rain-fall was in 1845, amounting to..............14·78
The greatest rain-fall was in 1853, amounting to........37·98

(Signed) Philip L. Hart,
Captain Engineers, on Special Duty.

C.

Return of the Water gauged at the Great Konduwah Nullah, from the 24th February to the 10th June, 1857.

February, 1857.			March, 1857.			April, 1857.			May, 1857.			June, 1857.			Remarks.
Date.	Cubic feet per hour.	Gallons per hour.	Date.	Cubic feet per hour.	Gallons per hour.	Date.	Cubic feet per hour.	Gallons per hour.	Date.	Cubic feet per hour.	Gallons per hour.	Date.	Cubic feet per hour.	Gallons per hour.	
24th	18·62	116	7th	270	1682·1	2nd	270	1682·1	2nd	154·28	961·16	1st	Nulla down.		From the 24th to the 26th February, 1857, the Nullah was gauged a little below Captain Graham's site for his proposed dam. A few days after the Nullah dried up at this spot, and on the 7th March the gauging was recommenced close to the village of Great Kondwah, not far from the spot the village Mhars procure their water from, and one of the most prolific situations in the whole length of the Nullah, being below some copious springs. The underground drainage finding its way into this stream is very considerable. There are no less than seventeen Pawn gardens situated on its banks, watered by twenty wells, sunk, of course, considerably below its bed, but the water from which feeds them.
26th	14·59	90·89	12th	270	1682·1	6th	270	1682·1	6th	135	841·05	3rd	270	1682·1	
			14th	270	1682·1	8th	216	1345·68	7th	135	841·05	4th	270	1682·1	
			16th	270	1682·1	10th	216	1345·68	9th	135	841·05	5th	270	1682·1	
			18th	270	1682·1	14th	180	1121·4	14th	270	1682·1	6th	270	1682·1	
			21st	308·56	1922·32	15th	180	1121·4	16th	216	1345·68	9th	216	1345·68	
			24th	240	1495·2	16th	180	1121·4	18th	216	1345·68				
			27th	270	1682·1	18th	180	1121·4	19th	180	1121·4				
						21st	180	1121·4	20th	180	1121·4				
						24th	180	1121·4	21st	180	1121·4				
						28th	180	1121·4	23rd	180	1121·4				
						30th	180	1121·4	25th	270	1682·1				
									26th	Nulla down.					
									27th	360	2242·8				
									28th	270	1682·1				
									29th	360	2242·8				
									30th	270	1682·1				
Average 103·4 gallons per hour.			Average 1,688·7 gallons per hour.			Average 1,252·2 gallons per hour.			Average 1,367·2 gallons per hour.			Average 1,614·8 gallons per hour.			

Camp Poona, October 23rd, 1857.

(Signed) Philip L. Hart,
Captain Engineers, on Special Duty.

Return of the Water gauged at the back of the Upper Kartriz Tank, from the 23rd February to the 9th June, 1857.

February, 1857.			March, 1857.			April, 1857.			May, 1857.			June, 1857.		
Date.	Cubic feet per hour.	Gallons per hour.	Date.	Cubic feet per hour.	Gallons per hour.	Date.	Cubic feet per hour.	Gallons per hour.	Date.	Cubic feet per hour.	Gallons per hour.	Date.	Cubic feet per hour.	Gallons per hour.
23rd	54·0	336·4	4th	77·14	480·5	3rd	46·95	202·4	1st	20·76	129·3	2nd	45·0	280·3
25th	72·0	448·5	6th	77·14	480·5	7th	37·24	232·0	6th	18·0	112·1	4th	45·0	280·3
28th	72·0	448·5	9th	77·14	480·5	9th	36·0	224·2	8th	16·87	105·1	5th	45·0	280·3
			12th	77·14	480·5	10th	28·42	177·0	14th	90·0	560·7	6th	36·0	224·2
			13th	54·0	336·4	14th	20·76	129·3	16th	90·0	560·7	9th	33·75	210·2
			16th	45·0	280·3	17th	22·5	140·1	18th	77·14	480·5			
			17th	43·2	269·1	21st	22·5	140·1	19th	77·14	480·5			
			19th	43·2	269·1	23rd	22·5	140·1	20th	77·14	480·5			
			20th	41·53	258·7	25th	22·5	140·1	21st	77·14	480·5			
			23rd	54·0	336·4	27th	22·5	140·1	23rd	77·14	480·5			
			26th	54·0	336·4	29th	20·76	129·3	25th	77·14	480·5			
			30th	45·5	280·3				26th	77·14	480·5			
									27th	90·0	560·7			
									28th	90·0	560·7			
									29th	67·5	420·5			
									30th	54·5	336·4			
Average 411·1 gallons per hour.			Average 357·4 gallons per hour.			Average 171·4 gallons per hour.			Average 419·4 gallons per hour.			Average 255·1 gallons per hour.		

Remarks.

The point where these measurements were taken was close behind the Bund wall of the upper tank, so as to embrace the water issuing from the tank itself, the leaking through it, and the water escaping from a spring behind the eastern end of the Bund wall. The tank gradually dried up to the 13th May; the water very rapidly decreasing, until a space was left in the deepest part of it round the steps of about 28,000 square feet. On the 13th, 26th, & 27th May heavy showers fell, which increased the supply. At the end of July the tank was almost dry.

From a careful observation of this effete work, I am of opinion the tank in its present state as a supply is not to be depended on. No doubt by tapping the deposit with which it is perhaps two-thirds filled, a considerable quantity of water would be obtained. I should say the evaporation in this extensive shallow expanse was in all possibility very considerable.

(Signed) Philip L. Hart,
Captain Engineers, on Special Duty.

Camp Poona, October 23rd, 1857.

Return of the Water gauged at the Large Nullah of the Ambeygaum Valley from the 24th February to the 8th June, 1857.

February, 1857.			March, 1857.			April, 1857.			May, 1857.			June, 1857.			Remarks.
Date.	Cubic feet per hour.	Gallons per hour.	Date.	Cubic feet per hour.	Gallons per hour.	Date.	Cubic feet per hour.	Gallons per hour.	Date.	Cubic feet per hour.	Gallons per hour.	Date.	Cubic feet per hour.	Gallons per hour.	
24th	360·0	2242·8	4th	308·56	1922·3	1st	196·36	1223·3	1st	120·0	747·6	2nd	Kutcha dam		
25th	308·56	1922·3	7th	308·56	1922·3	2nd	196·36	1223·3	6th	120·0	747·6		washed away.		
27th	308·56	1922·3	12th	270·0	1682·1	3rd	180·0	1121·4	8th	108·0	672·8	3rd	Rebuilding it.		This Nullah was gauged about 1,000 feet above the site of the proposed dam. Heavy showers on the 22nd and 25th May.
			16th	270·0	1682·1	7th	180·0	1121·4	13th	Kutcha dam		4th	180·0	1121·4	
			19th	308·56	1922·3	8th	154·28	961·1		washed away.		6th	180·0	1121·4	
			21st	216·0	1345·6	9th	135·0	841·0	14th	Rebuilding it.		8th	180·0	1121·4	
			25th	196·36	1223·3	10th	135·0	841·0	15th	180·0	1121·4				
			28th	216·0	1345·6	13th	135·0	841·0	16th	180·0	1121·4				
						14th	135·0	841·0	19th	180·0	1121·4				
						15th	135·0	841·0	21st	154·28	961·1				
						16th	135·0	841·0	22d	154·28	961·1				
						18th	135·0	841·0	23rd	180·0	1121·4				
						22d	135·0	841·0	26th	270·0	1682·1				
						25th	135·0	841·0	28th	Nulla down.					
						27th	135·0	841·0	29th	180·0	1121·4				
						29th	135·0	841·0							
Average 2,029·1 gallons per hour.			Average 1,630·7 gallons per hour.			Average 931·4 gallons per hour.			Average 1,034·4 gallons per hour.			Average 1,121·4 gallons per hour.			

Camp Poona, October 23rd, 1857.

(Signed) PHILIP L. HART,
Captain Engineers, on Special Duty.

General Result of the Gauging of these three Sites.

Month and Year.	* Burra Kondwah Nullah.	Back of the Upper Kartriz Tank.	Ambeygaum Nullah.
1857.	Gallons per hour.	Gallons per hour.	Gallons per hour.
March ..	1,688·7	357·4	1,430·7
April ..	1,252·2	171·4	931·4
May ..	1,367·2	419·4	1,031·4
June ..	1,614·8	255·1	1,121·4
	Average 1,480·7 gallons per hour.	Average 300 gallons per hour.	Average 1,179·4 gallons per hour.

Note.—The two days in February have been omitted, as the period is too short to take an average of to be of any use.

General Remarks.

From these results it will be seen that the supply of the Great Kondwah Valley is the greatest, which coincides with the opinion formed of it from frequent personal observation. This valley is in general character flat and open, and the bed in the lower portions formed of an alluvial soil resting on a sort of white marl. The rain percolates through this, and finds its way gradually to the lowest part of the valley, to the stream running at the bottom of it. What I intend to observe is, that the water percolates through the soil, not rapidly running off it. Large quantities of water are thus held in suspension, which however show but little on the surface, but which an excavation of moderate depth quickly discovers. There are consequently various springs on its banks, and twenty wells working to supply seventeen Pawn gardens. An excavation to a few feet below the bed of the Nullah on its banks soon reaches water.

With respect to the storage capacity of the Upper Kartriz Tank, it cannot, I think, be depended on for a full and constant supply of water. The shallowness of this large expanse does not seem adapted for storage. The evaporation must, I should say, be very rapid. There is doubtless a large supply held in suspension by the deposit, with which I should say the tank was almost 2-3rds filled up. This has only to be tapped, and led out at the back of the Bund, but what the supply would be, thus obtained, it is almost impossible to conjecture.

The supply of water to the Ambeygaum Valley from these gaugings, though less than that of the Great Kondwah Valley, is fully adequate to the supply of a large reservoir. The valley is surrounded by hills on all sides, and, as compared with the latter, has little alluvial soil in its bed, the soil being generally of moorum with a few feet of reddish earth above, except in the lower part of it near the village, where it is proposed to construct the dam. There is consequently little percolation or under-ground drainage, and but few springs, the water rapidly rising, sweeping down like a torrent, and soon running off. There are not more than two or three wells on its banks. With respect to its capabilities for storage and as a catchment basin, it possesses, I think, great natural advantages.

(Signed) Philip L. Hart,
Captain Engineers, on Special Duty.

Camp Poona, 23rd October, 1857.

D.

Calculations to determine the Diameter of the Conduit Pipe, the Masonry Aqueduct, the Discharge through the holes in the Iron Tube of the Inlet Tower, and through the orifices in the sides of the Distributing Reservoir.

THE CONDUIT PIPE.

Total length of the pipe is 27,343 feet = 5 m. 1 fur. 94⅓ yds.
Total fall is 80 feet.
The discharge is 1·52 cubic feet per second.

			Inches.
1. By Hawksley's formula,	the diameter will be	....	11·20
2. By Beardmire's ditto,	ditto	....	10·71
3. By De Prony's ditto,	ditto	....	13·46
4. By De Buat's ditto,	ditto	....	10·64

(1) $$d = \tfrac{1}{15}\sqrt{\frac{9^2\, l}{h}}$$

(2) $$x \quad 0{\cdot}235 \sqrt[5]{\frac{9^2 \times l}{h}}$$

(3) $$d = \sqrt[5]{\frac{4{\cdot}9^2}{(53{\cdot}58 \times {\cdot}7854)^2\, J}}$$

(4) $$v = \frac{307\,(\sqrt{d}-0{\cdot}1)}{\sqrt{s-h\,l}\;\sqrt{s+1{\cdot}6}} - {\cdot}3\,(\sqrt{d}-0{\cdot}1)$$

THE MASONRY AQUEDUCT.

Total length of the aqueduct is 41,116 feet = 7 m. 6 fur. 65⅓ yds.
Total fall is 80 feet.
Discharge 1·52 cubic feet per second.

		Inches.
1. By De Buat's formula, the side of the aqueduct is.		9·96
2. By De Prony's formula,	ditto .	9·94
3. By formula in Weale's Rudimentary Treatise, the side of the aqueduct is..................		10·80
4. By formula in the Aide Mémoire, the side of the aqueduct is............................		11·16
5. By Tardini's formula, the side of the aqueduct is.		13·32

(1) $$v = \frac{307\,(\sqrt{d}-0{\cdot}1)}{\sqrt{s-h\,l}\,\sqrt{s}+1{\cdot}6} - 0{\cdot}3\,(\sqrt{d}-0{\cdot}1)$$

(2) $$\frac{S^3}{P} = \frac{1}{\phi}(a\,Q\,S + b\,Q^2)$$

(3) $$S\sqrt{\frac{S}{P}} = \frac{\sqrt{Q^2 + \frac{1}{\phi}}}{(91{\cdot}441)^2}$$

(4) $$S\sqrt{\frac{S}{C}} = \frac{\sqrt{Q^2 \times \frac{1}{\phi}}}{2736}$$

(5) $$l\,h\,\sqrt{h} = \frac{Q\sqrt{\frac{1}{\phi}}}{50}$$

DISCHARGE THROUGH THE HOLES IN THE IRON TUBE OF THE INLET TOWER.

$Q = 5{\cdot}1086\, d^2\, T \sqrt{H}.$

				Cubic feet.
The discharge per second at the depth		of 2	feet is ..	1·80
Ditto	ditto	4	,, ..	2·55
Ditto	ditto	6	,, ..	3·12

DISCHARGE THROUGH THE ORIFICES IN THE SIDES OF THE DISTRIBUTING RESERVOIR.

$Q = 4{\cdot}978\, A\, T \sqrt{H}.$

				Cubic feet.
The discharge per second at the depth		of 2	feet is ..	1·38
Ditto	ditto	4	,, ..	1·95
Ditto	ditto	6	,, ..	2·39

(Signed) PHILIP L. HART,
Captain Engineers, on Special Duty.

Poona, 23rd October, 1857.

E.

Calculations of the Contents of the Distributing Reservoir, to hold One or Two Days' Supply.

RESERVOIR TO HOLD ONE DAY'S SUPPLY.

Pop. Day Gall.

$\frac{40,000 \times 2 \times 20}{6 \cdot 23} = 256,821$ cubic feet = two days' supply.

$\frac{256,821}{2} = 128,410$ cubic feet = one day's supply.

	Ft. long.	ft. broad.	ft. deep.			Cubic feet.
Reservoir	201 ×	110 ×	7 =		....	154,770
Deduct,—Two distributing cisterns,						
		2 × 26 × 13 × 7 =			4,732	
,, One foot above top water,						
		201 × 110 × 1 =			22,110	
						26,842
Cubic feet					....	127,928
Contents required					....	128,410
Less than requirement by					....	482

RESERVOIR TO HOLD TWO DAYS' SUPPLY.

Two days' supply as above, cubic feet 256,821.

	Ft. long.	ft. broad.	ft. deep.			Cubic feet.
Reservoir	270 ×	165 ×	7 =		....	311,850
Deduct,—Two distributing cisterns as above					4,732	
,, Division wall 165 n^o $\overline{2 \times 13}$						
		= 139 × 7 × $2\frac{1}{2}$		......	2,432	
,, One foot above top water,						
		270 × 165 × 1 =		....	44,550	
						51,714
Cubic feet					.. ..	260,136
Contents required					....	256,821
In excess of requirement					....	3,315

(Signed) PHILIP L. HART,
Captain Engineers, on Special Duty.

Poona, October 23rd, 1857.

F.

Calculations for the Cisterns of the Camp Distribution.

	Population.	Cattle.	Total.	Gallons per day.	Cubic feet per day.
Two Troops of Horse Artillery, and European Company of Artillery, with Light Field Battery	1,674	680	5,354	107,080	17,187·8
Three Companies of Sappers and Miners ..	1,363	64	1,427	28,540	4,581·5
One European Infantry Regiment	2,410	149	2,589	51,780	8,311·3
Ditto ditto ditto	2,110	119	2,589	51,780	8,311·3
One Native Infantry Regiment	2,317	139	2,456	49,120	7,884·4
Ditto ditto ditto	2,317	139	2,456	49,120	7,884·4
Ordnance Department	515	32	547	10,940	1,756·0
Bazar, Commissariat, Pensioners, &c......	17,828	1,686	19,514	390,280	62,645·2
Staff, Civilians, &c.	600	150	750	15,000	2,407·7
Total....	34,494	3188	37,682	753,640	120,969·6

Population 37,682 × 20 gallons daily = 753,640.

Number of Cisterns required.

	Requirements in Cubic Feet per Day.	No. of Cisterns.	Size of Cisterns.	Cubical Contents of Cisterns.
Two Troops of Horse Artillery, and European Company of Artillery, with Light Field Battery	17,187	4	25 × 18 × 8	14,400
		1	15 × 10 × 8	1,200
Three Companies of Sappers and Miners ..	4,581	1	25 × 18 × 8	3,600
		1	15 × 10 × 8	1,200
One European Infantry Regiment	8,311	2	25 × 18 × 8	7,200
		1	15 × 10 × 8	1,200
Ditto ditto ditto	8,311	2	25 18 × 8	7,200
		1	5 × 10 × 8	1,200
One Native Infantry Regiment	7,884	2	25 × 18 × 8	7,200
		1	15 × 10 × 8	1,200
Ditto ditto ditto	7,884	2	25 × 18 × 8	7,200
		1	15 × 10 × 8	1,200
Ordnance Department	1,756	2	15 × 10 × 8	2,400
Bazar, Commissariat, Pensioners, &c.......	62,645	11	25 × 18 × 8	39,600
		2	15 × 10 × 8	2,400
		2	Malcolm Tanks.	20,866
Staff, Civilians, &c.	2,407	2	15 × 10 × 8	2,400
Total....	120,966	36		121,666

In all, cisterns, thirty-six in number, of the following sizes, will be required :—

	Cubic feet.
Large 24, each 25 × 18 × 8 = ...	86,400
Small 12, each 15 × 10 × 8 = ...	14,400
Contents of the Malcolm Tanks*......	20,886
Total	121,666
Actual requirements	120,966
In excess	700

(Signed) PHILIP L. HART,
Captain Engineers, on Special Duty.

Poona, October 23rd, 1857.

G.

List of the different Lengths of Piping which will be required for the Camp Distribution, from the Distributing Reservoir to the various Cisterns, as actually chained on the ground.

	Feet.
From Distribution Reservoir to Hospital old European Barracks	350
From the above to the proposed new Artillery Hospital	972
From the above to the proposed new Artillery Patcherry	900
From the last to the centre of one of the sides Horse Artillery Horse Lines	1,500

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* Calculation of the contents of the Malcolm Tanks :—

Depth.		Length.		Width.		Cubic feet.
4·583	×	63·666	×	29·75 = ...		8,680·493
4·583	×	63·708	×	29·833 = ...		8,710·453
5·833	× 10 ×	No. 2	×	29·75 = ...		3,470·635
				Total.................		20,861·581
				By another calculation....		20,866·0

	Feet.
From the last to the front of Horse Artillery Officers' Lines	1,180
From proposed new Artillery Patcherry to Horse Artillery Barracks	870
From Hospital old European Barracks to centre of new Wanowree Barracks	1,400
From the last to the front of new Patcherry	900
From the last to Native Infantry Lines	3,200
From Native Infantry Lines to Native Infantry Hospital	700
From Native Infantry Lines to centre of Native Infantry Lines	900
From the last to the flank of Native Infantry Lines	1,047
From the last to the Tent Lascars' Lines	1,200
From the last to the Hospital Ghorepore Barracks.	2,700
Branch to the front and rear of the Ghorepore Barracks 1000 + 800	1,800
From Distribution Reservoir to opposite Compound No. 90	1,300
From the last to the Solitary Cells	2,360
From the last to the Camel Lines 1,930 + 760	2,690
From the Solitary Cells to the Commissariat Compound	1,400
From the last to corner of Compound No. 54	968
From last branch to near the old burying ground	1,100
From the last to the Malcolm Tanks	1,374
A branch from the above branch 400 + 650	1,050
From Compound No. 54 to Compound No. 31	1,460
From ditto to Bazar Guard	1,200
From Bazar Guard to West Street	790
From Compound No. 31 to Arsenal Compound	1,190
Branch from the last to the front of Mr. Partridge's shop	890
From Arsenal Compound to between Hospital Native Infantry and the Executive Engineer's Office Compound	1,300

	Feet.
From last to the Sappers and Miners' Lines	2,420
From Arsenal Compound to the corner of the Gym Khana	1,860
From the last to the Bund Road corners of His Excellency the Commander in Chief's Compound..	2,100
From corner of Gym Khana to open space near Compound No. 19	1,000
From Compound No. 19 to the rear of the Revenue Commissioner's Office	1,100
Total length in feet	47,171

Or in miles, yards, and feet .. 8 m. 1,643 yds. 2 ft.

(Signed) Philip L. Hart,
Captain Engineers, on Special Duty.

Poona, October, 1857.

POONA DIVISION.—PUBLIC WORKS.

CIVIL.

ESTIMATE framed by Captain P. L. Hart, of the Engineers, on special duty, of the probable expense of supplying the Poona Cantonment with water from the Ambeygaum Valley. Estimate framed agreeably to instructions contained in the Government Resolution, under Mr. Secretary Hart's Memorandum No. 160, of the 17th January, 1857.

		Rupees.
1.	Embankment	1,52,064
2.	Waste weir	10,517
3.	Artificial cut to carry off first floods	24,651
4.	Inlet tower and filter	12,172
5.	Gangway	9,082
6.	Masonry aqueduct and tunnel	1,14,969
7.	Iron conduit pipe and tunnel	1,85,434
8.	Distribution reservoir, for two days' supply	36,834
9.	Distribution reservoir, for one day's supply	22,599
10.	Camp distribution	1,03,409

GENERAL DESCRIPTION.

The general description of the scheme now submitted is as follows:—

The construction of an earthen dam across the gorge of the valley near the village of Upper Ambeygaum, 1,270¼ feet in length, its greatest height above the bed of the stream being 59·86 feet. From the reservoir so formed the water will be led, by either an iron conduit pipe, or masonry aqueduct, whichever may be considered the best and most economical, to the most favourable point for crossing the small plateau of the spur dividing the Kartriz and Ambeygaum valleys. Through this portion a tunnel will be driven 2,781½ feet long, opening at the head of the Duncowree Valley. The course then,

for either pipe or masonry aqueduct, will be down this little valley for some short distance. If by an iron conduit pipe, it will run almost straight to a distributing reservoir, to contain either one or two days' supply, near the solitary cells in the Camp of Poona; if by a masonry aqueduct, before reaching the mouth of the Duncowree Valley, it will branch off, running slightly up the Kartriz Valley, crossing the aqueduct, round under the village of Beebee Warree, and thence following the sinuosities of the hills to the distributing reservoir above mentioned, from which water can be delivered by gravitation to every part of the Cantonment, wherever required. If by a masonry aqueduct, the length will be 7 m. 6 fur. 65$\frac{1}{3}$ yds.; if by an iron pipe, it will be 5 m. 1 fur. 94$\frac{1}{3}$ yds., the total fall from the bottom of the main reservoir to the Camp distribution reservoir being 80·25 feet. The distributing reservoir, as above observed, will either contain one or two days' supply, and from it the water will be conveyed, by iron pipes of four and five inches diameter, to cisterns corresponding in number and capacity with the wants of the locality, with a stand-pipe at each cistern, the pipes always remaining charged. Plans Nos. 1 and 8 show these works.

EMBANKMENT.

The site occupied by the embankment, the details of which are shown in the Plan No. 2, to be cleared of all loose soil or soft rock, so that it may rest on the solid soil or clay, to the average depth of one foot over the whole surface so occupied; and on approaching the hill sides at each end, the ground to be regularly stepped or leached, in order that these portions may rest on a fair and horizontal base. An excavation for the trench intended to receive the puddle to be taken down to such a depth as will enable the puddle to rest either on solid rock, or on such a permanently secure base as will effectually prevent all leakage of water. The trench will also be stepped into the hill sides, in order that the puddle may have a fair bearing to rest on. The dotted line coloured yellow in Plan No. 2 shows the probable depth that the puddle trench will require to be excavated, and was ascertained from pits sunk at certain distances apart throughout the whole length of the embankment. The trench to be filled in with clay, well watered, in layers of six or eight inches in depth, and each layer to be well worked up with the feet. Particular

care must be taken to ensure its thorough consistency throughout, by always keeping the surface left well watered, so as to obtain a thorough junction with the next layer it may receive; this must extend throughout the whole puddle wall. It is to be eight feet wide at top, carried up to the summit of the embankment, and increasing in width at the rate of four feet for each ten feet of depth. All stones of more than half a pound weight, or other extraneous matter than good plastic clay, to be rejected, and all lumps and clods to be broken up and pounded, before being worked into the trench. There must be a uniform consistency throughout in this portion of the work, and no joints, seams, or cracks of any sort or description whatever allowed. The puddle wall and embankment to be carried on simultaneously, and no one portion of the puddle allowed to rise above the adjoining portion of the embankment.

The embankment to be twenty feet wide at top, with a slope on the inside of 3 to 1, and on the outside of 2 to 1, formed of the materials to be found close at hand; the best or most clayey portion to be put in the middle next to the puddle wall on the upstream side, and the least clayey on the outside half of the embankment. All stones exceeding three inches in diameter to be rejected. The embankment to be formed in parallel layers of about nine inches in thickness, inclining from both faces towards the puddle wall at a slope of 1 in 10. Each layer to be well watered, and pounded with wooden rammers, so that it may be thoroughly consolidated, the layers being kept of a uniform thickness throughout. The internal slope, the top, and for a length of ten feet of the external slope of the embankment, to be covered with dry stone pitching set carefully by hand, each stone on its end, two feet in depth, and resting on a bed of quarry shivers and broken stone, nine inches deep. The stones of which the pitching is formed to be of a general uniform thickness throughout, not tailing to a point, but with a fair, but rough, bed throughout the whole depth of two feet, and resting on an end similar to the face; the interstices to be carefully filled in with stone chippings. The face of this rough stone pitching to have an even and true surface throughout, and not to have that wavy appearance which bad work would denote. The surface to be as even as a well-built rubble masonry wall. A small rubble masonry wall to run along the foot of the internal slope (see Plan No. 2), the top being on a level with

the ground, for the rough stone pitching to abut against. This wall will tend to prevent any uneven settlement of the pitching, and preserve for it a true and even face.

THE WASTE WEIR.

A waste weir to be carried round the eastern end of the embankment, as shown in Plans Nos. 3 and 6, by an excavation in the solid ground 841 feet in length, and 100 feet in breadth, communicating with the "artificial cut to carry off the first floods" at its lower end The side slopes of this channel have been calculated at $\frac{1}{2}$ to 1, but, as the excavation throughout will most probably be in moorum, so large a slope will not be necessary; a deduction has consequently been made in the estimate of 25 per cent. from the solid contents. At the lower end of the waste weir, a masonry apron, with dwarf walls on each side, is to be built, to prevent the water working a channel for itself between the masonry of the apron and the adjoining soil. The foundation of the apron to be of uncoursed rubble masonry, with a rough slab pavement set on end in lime above it, two feet thick. The cross walls, at the upper and lower end of the apron, to be sunk below the foundation, to prevent the water from undermining it in any way.

ARTIFICIAL CUT TO CARRY OFF THE FIRST FLOODS.

The artificial cut is shown in Plans Nos. 3 and 6 in detail. It is to be 7,900 feet in length, with a breadth at base of 40 feet, side slopes calculated at $\frac{1}{2}$ to 1, but the same deduction to be made, on the account above stated. On leaving the bed of the Ambeygaum Nullah above the dam it runs for a length of 2,739 feet with a fall of 4·92 inches per 100 feet; for 1,615 feet with a fall of 1·85 inch to 100 feet; for 1,842 feet with a fall of 0·81 inch to 100 feet; for 715 feet with a fall of 6·29 inches to 100 feet, joining the stream again behind the embankment with a fall of 6·97 inches to 100 feet, in a length of 987 feet. This cut, crossing the three tributaries of the main stream, will require three small masonry dams to be built at the points of intersection, in addition to one across the main Nullah, at the point the artificial cut leaves it. The foundations of these dams to be carried down to the solid rock, to be built of uncoursed rubble masonry; the breadth of the dam at bottom to be of a thick-

ness equal to the height, and the top to be half the thickness at bottom, all to be built of uncoursed rubble masonry. Openings to be left in each, to enable the clear water to feed the reservoir after the first heavy monsoon muddy floods have passed off. For a further description, see paras. 46 to 49 of the Report accompanying.

INLET TOWER AND FILTER.

The details of this work are shown in Plan No. 5. The foundation of the inlet tower to be carried down 13 feet below the bed of the Nullah, or for such a further depth as may be found necessary, until a good foundation or solid rock be reached. On the foundation so excavated, a layer of *béton* to be laid over the whole extent (33 feet square), two feet deep, and on this a half-spherical invert to be turned of roughly-dressed stones, two feet deep, set in lime in concentric circles, having an inner diameter of 13 feet. • The work on the outside of the invert to be brought up in eight circular offsets of one foot in depth, and decreasing half a foot in breadth, of coursed rubble masonry, leaving the foundations at top 5½ feet thick, on which the walls of the tower rest. Openings to be left in the foundations and walls, as described previously, in para. 53 of the Report accompanying. On this half-spherical invert, the walls of the tower are to be carried up to a height of 60 feet, 5 feet thick at bottom, and 2½ feet thick at top, of coursed rubble masonry faced with cut-stone on both sides, particular care to be taken in the beds and joints, which are to extend at least one foot into the walls, and to be very close and fine, so as to secure a water-tight junction. At a height of about 15 feet above the foundation of the tower, there is to be a domed floor, set in concentric rings, of cut-stone masonry; the space included between the invert and this domed floor is the filter, the bottom part to be filled with amygdaloid,* and the upper portion with layers of coarse and fine sand. To communicate with the plugs in the iron tube, a circular staircase of roughly dressed stone, each stone to be well tailed into the walls of the tower, runs from the top of the tower to the domed floor. An iron tube, 3 feet in diameter, passes down the centre of the tower,

* A Scotch engineer, Mr. Thom, of much experience in works of this nature, found this species of friable trap rock, which abounds in the Deccan, the best substitute for animal charcoal, which is one of the most perfect filtering media.

and through the domed floor, provided at every two feet with spouts six inches in diameter, into which the wooden plugs are inserted for the supply of the tube, and winding spirally round it, to allow of their being easily closed or opened from the steps. A cut-stone cornice runs round the top of the tower, above which the walls are carried up 10 feet high, of coursed rubble masonry, with circular openings on three sides, covered with a teak-wood roof and double tiles. For any further particulars regarding this work, reference is requested to para. 53 of the Report accompanying, in which it is fully described. Ties of iron passing through the walls of the tower may, probably, be required to keep the tube firmly in its position; but, as the water in the upper part of the tower will always retain the same level as that outside, its pressure alone will probably be sufficient for this purpose. This subject is mentioned to show that it has not been lost sight of, though it is not thought necessary to provide for it in the estimate.

GANGWAY.

The foundation of the gangway pier, to be taken down to a depth of 10 feet, or such further depth as may be found necessary until a solid foundation is reached (Plans Nos. 2 and 4 show the details of this work), and to be filled in with rubble masonry. The superstructure to be carried up in three offsets of 19½, 20, and 17 feet respectively, of coursed rubble masonry, the thicknesses of the pier being respectively 6, 5, and 4 feet, in each division of its height. The pier, or abutment in the embankment, which will not be built until the lower portion has thoroughly consolidated, to be 12 feet in height, with a thickness of 4 feet, of coursed rubble masonry. The trusses of the gangway to be constructed of well-seasoned teak, procured for the most part from Bombay, free from cracks and knots, the Deccan timber not affording the length required. The castings to be clean and sound, and the wrought-iron work executed in a true and workmanlike manner, particularly the cutting of the threads of the screw-bolts and nuts, which are to be sharp and clean, with an even and true bearing for the nuts. All the joints of the wood-work to be close and truly fitted. The tongues between the timbers of the upper and lower chords to be of well-seasoned babool-wood, closely jointed. For further particulars of this work, see the description of it at para 55 of the Report accompanying.

MASONRY AQUEDUCT AND TUNNEL.

The total length of the masonry aqueduct, from the inlet tower to the distribution reservoir in the Camp, is 41,116 feet, or 7 miles 6 furlongs 65⅓ yards, divided into the following portions (Plans Nos. 7 and 8 contain the details of this work):—

	Length.	Inclination.
From the inlet tower to the mouth of th tunnel on the Ambeygaum side, the general section of the aqueduct is that shown at Fig. 1, except for a short distance where the aqueduct passes under the embankment (335 feet in length). Fig. 2 shows this section: it is precisely similar to that above, with the exception of the top being arched over, to prevent the weight of the embankment from crushing it in, which might probably occur with a section like Fig. 1	Feet. 4,729½	Inch. Feet. ¼ to 100
The section of the tunnel is similar to Fig. 3, of sufficient size to allow of two men driving it; where the tunnel joins the entrance shafts Nos. 5 and 8 (of Plans 7 and 8) a small extent of the length at the junction will probably require revetting, as shown in Fig. 4....	2,781½	Level.
Fig. 5 is the section of the aqueduct between chambered shafts Nos. 1 and 5 of Plan No. 8, viz. that portion of it which descends the Duncowree Valley..	2.570	Feet. Feet. 0·84 to 100
On account of the considerable fall, and the probability that a large quantity of water can be stored in this part of the aqueduct during the hot weather, it has been made of a larger and stronger section. It is highly probable that there will be no necessity, in many		

Fig 1

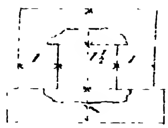
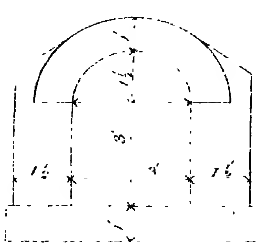


Fig 2

Fig 3

Fig 4

Fig 5



	Length.	Inclination.
parts, for either a masonry sill or side walls, as the excavation will be in rock; it has, however, been considered best to provide for it in the estimate. The same remark will apply to the aqueduct, having sections similar to Figs. 1 and 2.	Feet. 1,397	Feet. Feet. 1·81 to 100
From No. 1 chambered shaft to the distribution reservoir in the Camp, the section is similar to Fig. 1, which is the general section of the aqueduct throughout, it only having been departed from in the places where it has been considered as actually necessary	29,638	Inch. Feet. $\frac{1}{4}$ to 100

(Fig. 1.) This part of the aqueduct to be constructed of coursed rubble masonry, with slab-stones set in lime for the sole and top of the aqueduct.

(Fig. 2.) That portion passing under the embankment will be built in a similar manner to the above, with the exception of an arched head instead of a flat one.

(Fig. 3.) The section of the tunnel will be as shown in this figure, excepting those parts adjoining the entrance shafts, marked Nos. 5 and 8 of Plan No. 8, which will be revetted with coursed rubble masonry, for a distance at the junctions of 20 feet (see Fig. 4). The two shafts at the mouths of the tunnel, and the air-shafts, will be built of coursed rubble masonry.

(Fig. 5.) This section of the aqueduct will be constructed of coursed rubble masonry, the chambered shafts (Nos. 1, 2, 3, and 4) being of the same construction, but faced with cut-stone on the inside.

The trench for the aqueduct to be half filled in with the soil excavated from it, when that part of the work is finished.

IRON CONDUIT PIPE AND TUNNEL.

The iron conduit pipe leaves the inlet tower for a length of 4,729$\frac{1}{2}$ feet, at a slope of a quarter of an inch to 100 feet to the mouth of the tunnel, through which it is laid level for a length of 2,781$\frac{1}{2}$ feet. It then descends at a slope of 0·84 foot to 100 feet, for a distance of

2,570 feet, to the chambered shaft (No. 3) covering the spring, shown in Plans Nos. 7 and 8. The water entering one compartment of the shaft is discharged into the other, from the bottom of which the pipe proceeds, with various rises and falls, to the distribution reservoir in the Camp, the head of water to overcome which is 31 feet. For a further description of this portion of the work, see paras. 56 and 57 of the Report accompanying; Plan No. 7 showing the details, and Plan No. 8 a longitudinal section of the conduit pipe, from the bed of the Nullah at Ambeygaum to the distribution reservoir.

DISTRIBUTION RESERVOIRS (TWO AND ONE DAY'S SUPPLY).

Details of these works will be seen in Plans Nos. 6 and 7. The foundations of the retaining walls to be of uncoursed rubble masonry, faced with cut-stone on the inside. The foundation of the surrounding wall of the reservoir to be of the same construction as the above; the superstructure to be built of coursed rubble masonry with a cut-stone coping, and to be furnished with two strong teak-wood plank battened doors. The space between the foundations of these two walls, particularly to the sloping portions on the north side, and the lower parts of the east and west ends, to be filled in with earth in regular layers, well rammed, to prevent leakage. The bed of the reservoir throughout to be paved with cut-stone. In the event of this head of water being made use of for flushing sewers or drains (to be hereafter built throughout the Cantonment), two sluices will be required; they have not been included in the estimate, as they do not properly belong to the water supply of the Camp. For further particulars regarding these works, see paras. 62 and 63 of the Report accompanying, and letters E and F of the Appendix to it.

CAMP DISTRIBUTION.

The retaining walls of the cisterns to be built of coursed rubble masonry, with a cut-stone facing on the inside; a parapet wall of cut-stone to surround the cistern at the top. The bottom of the cistern, and the part surrounding the parapet wall at top, to be paved with cut-stone. The iron pipes conveying the water from the distributing reservoir to be of the kind usually denominated socket-pipes; to be perfectly sound, and free from honeycombs or other defects in the casting, with a stand-pipe and stop-cock provided for each cistern. The details of the Camp distribution are shown in Plan No. 9.

No. 1.—THE EMBANKMENT.

MEASUREMENTS.

Stepping the Embankment into the Sides of the Hill.

PLAN No. 2. (RIGHT SIDE.)	No.	Length.	Breadth.	Depth.	Solid Feet.
1st Portion	1	9·5	$\frac{23·41+20}{2}$	$\frac{1·25}{2}$	128·97
2nd do.	1	10	$\frac{26·85+23·24}{2}$	$\frac{1·25}{2}$	157·15
3rd do.	1	10	$\frac{30·26+26·85}{2}$	$\frac{1·25}{2}$	178·46
4th do.	1	10	$\frac{33·67+30·26}{2}$	$\frac{1·25}{2}$	199·78
5th do.	1	10	$\frac{37·08+33·67}{2}$	$\frac{1·25}{2}$	221·09
6th do.	1	10	$\frac{40·49+37·08}{2}$	$\frac{1·25}{2}$	242·40
7th do.	1	10	$\frac{43·9+40·49}{2}$	$\frac{1·25}{2}$	263·71
8th do.	1	10	$\frac{58·91+43·9}{2}$	$\frac{1·67}{2}$	429·23
9th do.	1	10	$\frac{73·92+58·91}{2}$	$\frac{1·07}{2}$	554·56
10th do.	1	10	$\frac{88·95+73·92}{2}$	$\frac{1·67}{2}$	679·98
11th do.	1	10	$\frac{98·96+88·95}{2}$	$\frac{2}{2}$	939·55
12th do.	1	10	$\frac{108·97+98·96}{2}$	$\frac{3}{2}$	1,559·47
13th do.	1	10	$\frac{118·98+108·97}{2}$	$\frac{3}{2}$	1,709·62
14th do.	1	10	$\frac{135·15+118·98}{2}$	$\frac{3}{2}$	1,905·97
15th do.	1	10	$\frac{135·15+156·45}{2}$	$\frac{5}{2}$	3,645·00
16th do.	1	10	$\frac{156·45+168·52}{2}$	$\frac{3}{2}$	2,437·27
17th do.	1	10	$\frac{168·52+171·36}{2}$	$\frac{1}{2}$	849·70
18th do.	1	10	$\frac{171·36+181·78}{2}$	$\frac{2}{2}$	1,765·70
19th do.	1	10	$\frac{181·78+199·75}{2}$	$\frac{4}{2}$	3,815·30
(LEFT SIDE.)					
1st Portion	1	9·25	$\frac{20·0+33·14}{2}$	$\frac{1·3}{2}$	185·37
2nd do.	1	10	$\frac{33·44+46·88}{2}$	$\frac{2·5}{2}$	502·00
3rd do.	1	10	$\frac{46·88+60·32}{2}$	$\frac{2·5}{2}$	670·00

Stepping the Embankment into the Sides of the Hill—(continued).

	No.	Length.	Breadth.		Solid Feet.
4th Portion	1	10	$\frac{60·32+73·76}{2}$	$\frac{3·5}{2}$	1,173·20
5th do.	1	10	$\frac{73·76+87·20}{2}$	$\frac{3·5}{2}$	1,408·40
6th do.	1	10	$\frac{87·20+100·65}{2}$	$\frac{3·5}{2}$	1,643·68
7th do.	1	10	$\frac{100·65+122·52}{2}$	$\frac{4}{2}$	2,231·70
8th do.	1	10	$\frac{122·52+144·39}{2}$	$\frac{4·5}{2}$	3,002·73
9th do.	1	10	$\frac{144·39+166 26}{2}$	$\frac{4·5}{2}$	3,494·81
10th do.	1	10	$\frac{166·26+188·13}{2}$	$\frac{4 5}{2}$	3,986·88
11th do.	1	10	$\frac{188·13+210·00}{2}$	$\frac{3·5}{2}$	3,483 63
12th do	1	10	$\frac{210·00+219·85}{2}$	$\frac{1·5}{2}$	1,611·93
13th do.	1	10	$\frac{219·85+229·70}{2}$	$\frac{0·5}{2}$	561·93
14th do.	1	10	$\frac{229·70+239·55}{2}$	$\frac{2}{2}$	2,346 25
15th do.	1	10	$\frac{239 55+249·40}{2}$	$\frac{2·5}{2}$	3,055 93
16th do.	1	10	$\frac{249·40+259·25}{2}$	$\frac{2}{2}$	2,543·25
Total solid feet stepping the embankment in moorum ..					53,584·60

Stripping Loose Earth from the Bed of the Embankment.

PLAN No. 2. (FROM THE LEFT.)	No.	Length.	Breadth.	Depth.	Solid Feet.
1st Portion	1	58·5	$\frac{259 25+278·00}{2}$	1	15,740·88
2nd do.	1	116	$\frac{278·00+335·80}{2}$	1	35,652·60
3rd do.	1	6	$\frac{335·80+311·25}{2}$	1	1,941·15
4th do.	1	18·5	$\frac{311·25+319·30}{2}$	1	5,832·58
5th do.	1	32	$\frac{319·30+314·95}{2}$	1	10,148·00
6th do.	1	14	$\frac{314·95+295·95}{2}$	1	4,276·30
7th do.	1	40	$\frac{295·95+292·45}{2}$	1	11,768·00
8th do.	1	68·5	$\frac{292·45+270·25}{2}$	1	19,477·97

Stripping Loose Earth from the Bed of the Embankment—(continued).

	No.	Length.	Breadth.	Depth.	Solid Feet.
9th Portion	1	35·5	$\frac{276{\cdot}25+278{\cdot}05}{2}$	1	9,838·82
10th do.	1	47·5	$\frac{278{\cdot}05+280{\cdot}65}{2}$	1	13,411·62
11th do.	1	53·5	$\frac{280{\cdot}65+295{\cdot}15}{2}$	1	15,563·15
12th do.	1	46·5	$\frac{295{\cdot}15+294{\cdot}75}{2}$	1	13,695·17
13th do.	1	11	$\frac{294{\cdot}75+306{\cdot}60}{2}$	1	3,307·42
14th do.	1	24	$\frac{306{\cdot}60+289{\cdot}55}{2}$	1	7,153·80
15th do.	1	88·5	$\frac{289{\cdot}55+279{\cdot}85}{2}$	1	25,195·95
16th do.	1	9	$\frac{279{\cdot}85+266{\cdot}45}{2}$	1	2,458·35
17th do.	1	72·0	$\frac{266{\cdot}45+259{\cdot}85}{2}$	1	18,946·80
18th do.	1	9·5	$\frac{259{\cdot}85+243{\cdot}40}{2}$	1	2,390·43
19th do.	1	114	$\frac{243{\cdot}40+219{\cdot}85}{2}$	1	26,405·25
20th do.	1	57	$\frac{219{\cdot}85+199{\cdot}75}{2}$	1	11,958·60
Total solid feet stripping earth from the bed of the embankment					255,162·84

Excavating Foundation for the Dwarf Wall for the Pitching to abut against.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Dwarf wall at the foot of the embankment, up-stream side	1	1,377·38	3·66	4	20,164·84
Total solid feet of excavation for dwarf wall at the foot of the embankment, upstream side................					20,164·84

Excavating Trench to receive the Puddle.

PLAN No. 2. (FROM THE LEFT.)	No.	Length.	Breadth.	Depth.	Solid Feet.
1st Portion	1	11	$\frac{8+8{\cdot}87}{2}$	$\frac{5{\cdot}0}{1}$	463·92
2nd do.	1	24	$\frac{8{\cdot}87+11{\cdot}51}{2}$	$\frac{5{\cdot}0}{1}$	1,224·60
3rd do.	1	25·5	$\frac{11{\cdot}51+14{\cdot}45}{2}$	$\frac{5{\cdot}0}{1}$	1,656·86
4th do.	1	12·5	$\frac{14{\cdot}45+16{\cdot}68}{2}$	$\frac{5{\cdot}0}{1}$	972·81
5th do.	1	22	$\frac{16{\cdot}68+20{\cdot}74}{2}$	$\frac{5{\cdot}0}{1}$	2,058·10
6th do.	1	18·5	$\frac{20{\cdot}74+23{\cdot}67}{2}$	$\frac{5{\cdot}5+5}{2}$	2,156·66
7th do.	1	17·25	$\frac{23{\cdot}67+24{\cdot}16}{2}$	$\frac{5+7}{2}$	2,578·34
8th do.	1	28·5	$\frac{24{\cdot}16+27{\cdot}14}{2}$	$\frac{7{\cdot}0}{1}$	5,117·17
9th do.	1	58·5	$\frac{27{\cdot}14+28{\cdot}71}{2}$	$\frac{7+9{\cdot}5}{2}$	13,477·30
10th do.	1	116	$\frac{28{\cdot}71+28{\cdot}86}{2}$	$\frac{9{\cdot}5+12{\cdot}5}{2}$	36,729·66
11th do.	1	6	$\frac{28{\cdot}86+31{\cdot}30}{2}$	$\frac{12{\cdot}5+10{\cdot}5}{2}$	2,075·52
12th do.	1	18·5	$\frac{31{\cdot}30+31{\cdot}04}{2}$	$\frac{10{\cdot}5+9{\cdot}5}{2}$	5,849·70
13th do.	1	32	$\frac{31{\cdot}04+31{\cdot}59}{2}$	$\frac{9{\cdot}5+11}{2}$	10,418·92
14th do.	1	14	$\frac{31{\cdot}59+30{\cdot}07}{2}$	$\frac{11+14{\cdot}5}{2}$	5,503·15
15th do.	1	40	$\frac{30{\cdot}07+29{\cdot}79}{2}$	$\frac{14{\cdot}5+15}{2}$	17,658·70
16th do.	1	68·5	$\frac{29{\cdot}79+28{\cdot}50}{2}$	$\frac{15+19}{2}$	33,939·35
17th do.	1	35·5	$\frac{28{\cdot}50+28{\cdot}64}{2}$	$\frac{19+18{\cdot}5}{2}$	19,016·90
18th do.	1	47·5	$\frac{28{\cdot}64+29{\cdot}33}{2}$	$\frac{18{\cdot}5+17{\cdot}5}{2}$	24,782·17
19th do.	1	53·5	$\frac{29{\cdot}33+30{\cdot}01}{2}$	$\frac{17{\cdot}5+15}{2}$	25,794·35
20th do.	1	46·5	$\frac{30{\cdot}01+29{\cdot}98}{2}$	$\frac{15+15}{2}$	20,921·51
21st do.	1	11	$\frac{29{\cdot}98+30{\cdot}92}{2}$	$\frac{15+12{\cdot}5}{2}$	4,605·56
22nd do.	1	24	$\frac{30{\cdot}92+29{\cdot}56}{2}$	$\frac{12{\cdot}5+16}{2}$	10,342·08
23rd do.	1	88·5	$\frac{29{\cdot}56+28{\cdot}78}{2}$	$\frac{16+14{\cdot}5}{2}$	39,368·56
24th do.	1	9	$\frac{28{\cdot}78+27{\cdot}71}{2}$	$\frac{14{\cdot}5+16}{2}$	3,876·62
25th do.	1	72	$\frac{27{\cdot}71+27{\cdot}18}{2}$	$\frac{16+14{\cdot}5}{2}$	30,134·61
26th do.	1	9·5	$\frac{27{\cdot}18+25{\cdot}87}{2}$	$\frac{14{\cdot}5+17}{2}$	3,968·80

Excavating Trench to receive the Puddle—(continued).

	No.	Length.	Breadth.	Depth.	Solid Feet.
27th Portion..........	1	114	$\frac{25{\cdot}87+23{\cdot}08}{2}$	$\frac{17+11{\cdot}5}{2}$	40,490·66
28th do.	1	57	$\frac{23{\cdot}08+22{\cdot}38}{2}$	$\frac{11{\cdot}5+10}{2}$	14,203·54
29th do.	1	15	$\frac{22{\cdot}38+20{\cdot}22}{2}$	$\frac{10+12}{2}$	3,514·50
30th do.	1	19	$\frac{20{\cdot}22+19{\cdot}70}{2}$	$\frac{12+8}{2}$	3,798·10
31st do.	1	20·5	$\frac{19{\cdot}70+16{\cdot}36}{2}$	$\frac{8}{1}$	2,961·84
32nd do.	1	34·5	$\frac{16{\cdot}36+13{\cdot}51}{2}$	$\frac{8+5{\cdot}5}{2}$	3,477·98
33rd do.	1	30	$13{\cdot}51+11{\cdot}11$	$\frac{5{\cdot}5}{1}$	2,031·15
34th do.	1	71·5	$11{\cdot}11+8{\cdot}0$	$\frac{5{\cdot}5+7}{2}$	4,269·89

Total solid feet excavating trench to receive the puddle in earth, pebbles, and water .... 3,99,418·50

Building Dwarf Wall for Pitching to abut against.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Footing..............	1	1,377·38	3·66	1	5,041·21
Wall, 1st portion	1	1,377·38	2·66	1	3,663·83
,, 2nd do.	1	1,377·38	$\frac{2{\cdot}66+2}{2}$	2	6,418·59

Total solid feet of building dwarf wall for the pitching to abut against, of uncoursed rubble masonry ..... 15,123·63

Filling in Puddle Trench with Clay.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Same as the excavation above..............					3,99,418·50

Total solid feet of filling in puddle trench with clay.... 3,99,418·50

Constructing Puddle Wall of Embankment above the Trench filled in with Clay.

	No.	Length.	Breadth.	Depth or Height.	Solid Feet.
1st Portion	1	11	$\frac{8\cdot87+8}{2}+$	$\frac{2\cdot18}{2}$	98·58
2nd do.	1	24	$11\cdot54+8 \quad 8\cdot87+8$	$\frac{8\cdot87+2\cdot18}{2}$	1,206·99
3rd do.	1	25·5	$\frac{\frac{14\cdot15+8}{2}+\frac{11\cdot54+8}{2}}{2}$	$\frac{16\cdot13+8\cdot87}{2}$	3,346·07
4th do.	1	12·5	$\frac{16\cdot68+8}{2}+\frac{14\cdot15+8}{2}$	$21\cdot72+16\cdot13$	2,787·29
5th do.	1	22	$\frac{20\cdot71+8}{2}+\frac{16\cdot68+8}{2}$	$31\cdot85+21.72$	7,869·70
6th do.	1	18·5	$\frac{23\cdot67+8}{2}+\frac{20\cdot71+8}{2}$	$39\cdot18+31\cdot85$	9,932·75
7th do.	1	17·25	$\frac{24\cdot16+8}{2}+\frac{23\cdot67+8}{2}$	$40\cdot4+39\cdot18$	10,952·86
8th do.	1	28·5	$\frac{27\cdot14+8}{2}+\frac{24\cdot16+8}{2}$	$47\cdot85+40\cdot4$	21,158·48
9th do.	1	58·5	$\frac{28\cdot71+8}{2}+\frac{27\cdot14+8}{2}$	$51\cdot78+47\cdot85$	52,345·91
10th do.	1	116	$\frac{28\cdot86+8}{2}+\frac{28\cdot71+}{2}$	$57\cdot16+51\cdot78$	116,213·37
11th do.	1	6	$\frac{31\cdot30+8}{2}+\frac{28\cdot86+8}{2}$	$\frac{58\cdot25+57\cdot16}{2}$	6,592·21
12th do.	1	18·5	$\frac{31\cdot94+8}{2}+\frac{31\cdot30+8}{2}$	$\frac{59\cdot86+58\cdot25}{2}$	21,642·77
13th do.	1	32	$\frac{\frac{31\cdot59+8}{2}+\frac{31\cdot94+8}{2}}{2}$	$\frac{58\cdot09+59\cdot86}{2}$	37,808·56
14th do.	1	14	$\frac{30\cdot07+8}{}+\frac{31\cdot59+8}{}$	$55\cdot19+58\cdot09$	15,517·63
15th do.	1	40	$\frac{29\cdot79+8}{2}+\frac{30\cdot07+8}{2}$	$54\cdot49+55\cdot19$	41,601·62
16th do.	1	68·5	$\frac{28\cdot5+8}{2}+\frac{29\cdot79+8}{2}$	$51\cdot25+54\cdot49$	67,262·08
17th do.	1	35·5	$\frac{28\cdot64+8}{2}+\frac{28\cdot5+8}{2}$	$51\cdot61+51\cdot25$	33,384·11
18th do.	1	47·5	$\frac{29\cdot33+8}{2}+\frac{28\cdot64+8}{2}$	$53\cdot33+51\cdot$	46,106·88

Constructing Puddle Wall, &c.—(continued.)

	No.	Length.	Breadth.	Depth or Height.	Solid Feet.
19th Portion	1	53·5	$\frac{30{\cdot}01+8}{2}+\frac{29{\cdot}33+8}{2}$	5·03+58·33	54,595·69
20th do.	1	46·5	$\frac{\frac{29{\cdot}98+8}{2}+\frac{30{\cdot}01+8}{2}}{2}$	1·95+55·03	48,577·27
21st do.	1	11	$\frac{30{\cdot}92+8}{2}+\frac{29{\cdot}98+8}{2}$	$\frac{7{\cdot}32+51{\cdot}95}{2}$	11,871·14
22nd do.	1	24		3·91+57·32	25,520·61
23rd do.	1	88	$\frac{28{\cdot}78+8}{2}+\frac{29{\cdot}50+8}{2}$		87,074·25
24th do.	1	9			8,257·87
25th do.	1		$\frac{27{\cdot}18+8}{2}+\frac{27{\cdot}71+8}{2}$	$\frac{17{\cdot}07+19{\cdot}29}{2}$	62,052·85
26th do.	1	9·5	$\frac{25{\cdot}87+8}{2}+\frac{27{\cdot}18+8}{2}$	14·68+17·07	7,597·01
27th do.	1	114	$\frac{23{\cdot}98+8}{2}+\frac{25{\cdot}87+8}{2}$	9·07+14·68	79,432·38
28th do.	1	57	$\frac{22{\cdot}38+8}{2}+\frac{23{\cdot}98+8}{2}$	35·05+39·07	33,732·39
29th do.	1	15	$\frac{20{\cdot}22+8}{2}+\frac{22{\cdot}38+8}{2}$	30·56+35·05	7,307·78
30th do.	1	19	$\frac{19{\cdot}76+8}{2}+\frac{20{\cdot}22+8}{2}$	20·42+30·56	7,974·49
31st do.	1	20·5	$\frac{16{\cdot}36+8}{2}+\frac{19{\cdot}76+8}{2}$	9·90+20·42	6,720·61
32nd do.	1	34·5		13·79+20·90	6,865·17
33rd do.	1	30	$\frac{11{\cdot}11+8}{2}+\frac{13{\cdot}51+8}{2}$	$\frac{8{\cdot}78+13{\cdot}79}{2}$	3,437·97
34th do.	1	70·5	$\frac{80\ 8+8}{2}+\frac{11{\cdot}11+8}{2}$	0·00+8·78	2,716·59

Total solid feet constructing puddle wall of embankment .... 9,49,551·93

Covering Internal Slope and Top of Embankment with Rough Stone Pitching.

	No.	Length.	Breadth or Slope.	Square Feet.
INTERNAL SLOPE OF EMBANKMENT.			Hypotenuse.	
1st Portion	1	11	$\frac{6{\cdot}89+0{\cdot}00}{2}$	37·89
2nd do.	1	24	$\frac{28{\cdot}04+6{\cdot}89}{2}$	419·16
3rd do.	1	25·5	$\frac{51{\cdot}00+28{\cdot}04}{2}$	1,007·76
4th do.	1	12·5	$\frac{69{\cdot}48+51{\cdot}00}{2}$	753·00
5th do.	1	22	$\frac{100{\cdot}69+69{\cdot}48}{2}$	1,871·87
6th do.	1	18·5	$\frac{123{\cdot}88+100{\cdot}69}{2}$	2,077·27
7th do.	1	17·25	$\frac{127{\cdot}73+123{\cdot}88}{2}$	2,170·13
8th do.	1	28·5	$\frac{151{\cdot}28+127{\cdot}73}{2}$	3,975·89
9th do.	1	58·5	$\frac{163{\cdot}72+151{\cdot}28}{2}$	9,213·75
10th do.	1	116	$\frac{180{\cdot}72+163{\cdot}72}{2}$	19,977·52
11th do.	1	6	$\frac{184{\cdot}16+180{\cdot}72}{2}$	1,094·64
12th do.	1	18·5	$\frac{189{\cdot}29+184{\cdot}16}{2}$	3,454·41
13th do.	1	32	$\frac{186{\cdot}54+189{\cdot}29}{2}$	6,013·28
14th do.	1	14	$\frac{174{\cdot}49+186{\cdot}54}{2}$	2,527·20
15th do.	1	40	$\frac{172{\cdot}28+174{\cdot}49}{2}$	6,935·40
16th do.	1	68·5	$\frac{162{\cdot}04+172{\cdot}28}{2}$	11,450·46
17th do.	1	35·5	$\frac{163{\cdot}18+162{\cdot}04}{2}$	5,772·65
18th do.	1	47·5	$\frac{168{\cdot}62+163{\cdot}18}{2}$	7,880·25
19th do.	1	53·5	$\frac{174{\cdot}00+168{\cdot}62}{2}$	9,165·08
20th do.	1	46·5	$\frac{173{\cdot}73+174{\cdot}00}{2}$	8,084·72
21st do.	1	11	$\frac{185{\cdot}23+173{\cdot}73}{2}$	1,974·28
22nd do.	1	24	$\frac{170{\cdot}44+185{\cdot}23}{2}$	4,268·04
23rd do.	1	88·5	$\frac{164{\cdot}32+170{\cdot}44}{2}$	14,813·13
24th do.	1	9	$\frac{155{\cdot}84+164{\cdot}32}{2}$	1,440·72
25th do.	1	72	$\frac{151{\cdot}67+155{\cdot}84}{2}$	11,070·36

Covering Internal Slope, &c.—(continued.)

	No.	Length.	Breadth or Slope.	Square Feet.
INTERNAL SLOPE OF EMBANKMENT.			Hypotenuse.	
26th Portion	1	9·5	$\frac{141\cdot20+151\cdot67}{2}$	1,391·41
27th do.	1	114	$\frac{126\cdot38+141\cdot20}{2}$	15,255·48
28th do.	1	57	$\frac{113\cdot67+126\cdot38}{2}$	6,841·42
29th do.	1	15	$\frac{96\cdot62+113\cdot67}{2}$	1,577·17
30th do.	1	19	$\frac{93\cdot02+96\cdot62}{2}$	1,801·58
31st do.	1	20·5	$\frac{66\cdot08+93\cdot02}{2}$	1,630·77
32nd do.	1	34·5	$\frac{43\cdot60+66\cdot08}{2}$	1,891·98
33rd do.	1	30	$\frac{27\cdot76+43\cdot60}{2}$	1,070·40
34th do.	1	70·5	$\frac{0\cdot00+27\cdot76}{2}$	978·54
Top of embankment	1	1270·25	$\frac{20}{1}$	25,405·00
Part of external slope	1	1230·16	$\frac{10}{1}$	12,301·60
Total square feet covering internal slope and top of embankment with rough stone pitching, on a bottom of quarry shivers and loose small stones nine inches deep.				202,594·22

Forming Embankment.

	No.	Length.	Area of Prismoid.	Solid Feet.
1st Portion	1	70·5	152·04	10,718·82
2nd do.	1	30	549·30	16,479·00
3rd do.	1	34·5	1,109·554	38,279·61
4th do.	1	20·5	2,100·887	43,068·18

Forming Embankment—(continued).

	No.	Length.	Area of Prismoid.	Solid Feet.
5th Portion	1	19	2,848·571	54,122·84
6th do.	1	15	3,435·89	51,538·35
7th do.	1	57	4,364·97	2,48,803·29
8th do.	1	114	5,329·635	6,07,578·90
9th do.	1	9·5	6,293·769	59,790·80
10th do.	1	72	6,885·155	4,95,731·16
11th do.	1	9	7,422·588	66,803·29
12th do.	1	88·5	8,066·193	7,13,858·08
13th do.	1	24	8,847·292	2,12,335·00
14th do.	1	11	9,001·715	99,018·86
15th do.	1	46·5	8,659·551	4,02,669·12
16th do.	1	53·5	8,422·883	4,50,624·24
17th do.	1	47·5	7,932·768	3,76,806·48
18th do.	1	35·5	7,641·239	2,71,263·98
19th do.	1	68·5	8,047·679	5,51,266·01
20th do.	1	40	8,615·466	3,44,618·64
21st do.	1	14	9,292·978	1,30,101·69
22nd do.	1	32	10,016·983	3,20,543·45
23rd do.	1	18·5	9,900·372	1,83,156·88
24th do.	1	6	9,479·014	56,874·08
25th do.	1	116	8,512·882	9,87,494·31
26th do.	1	58·5	7,203·352	4,21,396·09
27th do.	1	28·5	5,761·602	1,64,205·65
28th do.	1	17·25	4,754·22	82,010·29
29th do.	1	18·5	3,874·781	71,683·44
30th do.	1	22	2,350·668	51,714·69
31st do.	1	12·5	1,280·399	16,004·98

Forming Embankment—(continued).

	No.	Length.	Area of Prismoid.	Solid Feet.
32nd Portion	1	25·5	651·605	16,615·92
33rd do.	1	24	196·138	4,707·31
34th do.	1	11	25·76	283·36

Total solid feet.... 7,622,166·79

Deduct puddle wall of embankment as above, cubic feet | 949,551·93

Total solid feet forming embankment .... 6,672,614·86

ABSTRACT.

Quantities.		Rs.	a.	p.
53,584	Solid feet stepping the embankment into the hill sides in moorum, at Rs. 0-10-6 per 100 solid feet	351	10	3
2,55,162	Solid feet stripping the earth from the bed of the embankment, at Rs. 0-4-0 per 100 solid feet	637	14	5
20,164	Solid feet of excavation for dwarf wall at the foot of the embankment up-stream side, in earth and gravel, at Rs. 0-7-0 per 100 solid feet	88	3	5
3,99,418	Solid feet of excavation for trench to receive the puddle in earth, gravel, and water, at Rs. 2-8-0 per 100 solid feet.	9,985	7	2
15,123	Solid feet of building dwarf wall for the pitching to abut against, of uncoursed rubble masonry, at Rs. 8 per 100 solid feet	1,209	13	5

ABSTRACT—(*continued*).

Quantities.		Rs.	a.	p.
3,99,418	Solid feet of filling in puddle trench with clay, at Rs. 1-2-0 per 100 solid feet..	4,493	7	2
9,49,551	Solid feet constructing puddle wall of embankment, at Rs. 1-2-0 per 100 solid feet	10,682	7	2
2,02,594	Square feet of covering internal slope of embankment, &c. with rough stone pitching set on end, on a bottom of quarry shivers and small stones nine inches thick, at Rs. 0-4-0 per square foot.	50,648.	8	0
66,72,614	Solid feet of forming embankment, at Rs. 1 per 100 solid feet............	66,726.	2	2
	Total	1,44,823	9	2
	Contingencies, at 5 per cent............	7,241	2	10
	Total amount for the embankment ..Rs.	1,52,064	0	0

No. 2.—WASTE WEIR.

MEASUREMENTS.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Total solid feet excavation for waste weir	..	..	..	..	8,12,325
Total solid feet excavation in moorum for waste weir					8,12,325

Apron to Waste Weir. Excavating Foundation.

	No.	Length.	Breadth.	Depth.	Solid Feet.
The wall at two ends		108	4	6	5,184
For the pavement ...		60	108	4	25,920
Outside of ditto.....		16	$\frac{108+135}{2}$	2	3,888
Total solid feet of excavating in moorum, for the foundation of the apron to the waste weir................					34,992

Uncoursed Rubble Masonry in Foundation of the Apron.

	No.	Length.	Breadth.	Depth.	Solid Feet.
End walls..................	2	$\frac{108+103}{2}$	4	6	5,064
Under the pavement	1	$\frac{108+103}{2}$	60	3	18,990
Small retaining wall, both sides of the apron......	2	68	1·5	3	612
Total solid feet of uncoursed rubble masonry in the foundation of the apron					24,666

Rough Stone Pavement in Waste Weir, set on Edge in Lime.

	No.	Length.	Breadth.	Square Feet.
Between small retaining walls	1	60	100	6,000
Outside of ditto ditto	1	16	$\frac{108+135}{2}$	1,944
Total square feet of rough stone pavement, set on edge in lime..				7,944

ABSTRACT.

Quantity.		Rs.	a.	p.
8,12,325	Solid feet of excavating in moorum for waste weir, at Rs. 0-10-6 per 100 solid feet	5,330	14	1
34,992	Solid feet of excavating in moorum for foundation of the apron, at Rs. 0-10-6 per 100 solid feet	229	10	1
24,666	Solid feet of uncoursed rubble masonry in the foundation for the apron, at Rs. 8 per 100 solid feet	1,973	4	5
7,944	Square feet of rough stone pavement set on edge in lime, at Rs. 0-5-0 per square foot	2,482	8	0
	Total ... Rs	10,016	4	7
	Contingencies, at 5 per cent.	500	13	0
	Total amount for waste weir ....Rs..	10,517	0	0

No. 3.—ARTIFICIAL CUT TO CARRY OFF THE FIRST MONSOON FLOODS.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Total solid feet of excavation in moorum in cut	..	..	..	..	30,97,396·87
Total solid feet of excavating in moorum for the artificial cut to carry off the first floods					30,97,396·87

ABSTRACT.

Quantity.		Rs.	a.	p.
30,97,396	Solid feet excavating artificial cut in moorum, at Rs. 0-10-6 per 100 solid feet . .	20,326	10	6
	Total. . Rs.	20,326	10	6
Contingencies, at 5 per cent.		1,016	5	3
Total amount for excavating artificial cut . . . . Rs. .		21,342	0	0

CONSTRUCTING MASONRY DAM ACROSS THE AMBEYGAUM NULLAH.

Excavating Foundation in Earth.

	No.	Length.	Breadth	Depth.	Solid Feet.
1st Portion from the left		10	8·70	$\frac{7·82+4·59}{2}$	539·83
2nd do.		3	8·70	$\frac{1·59+2·31}{2}$	90·04
3rd do.		4	8·70	$\frac{2·31+2·28}{2}$	19·86
4th do.		6	12·30	$\frac{7·17+1·24}{2}$	310·32
5th do.		11	12·30	$\frac{1·24}{2}$	83·88
6th do.		15	12·30	$\frac{0·95}{2}$	87·63
7th do.		4	12·30	$\frac{7·80+0·95}{2}$	215·25
8th do.		7	12·30	$\frac{7·80+9·58}{2}$	748·20
9th do.		20	8·86	$\frac{5·72+5·00}{2}$	949·79
Total solid feet excavating foundation in earth.					3,104·80

Excavating Foundation in Soft Rock.

	No.	Length.	Breadth.	Depth.	Solid Feet.
For foundation	1	43	12·30	2	1,057·80
Total solid feet excavating foundation in soft rock					1,057·80

Building Foundation of Uncoursed Rubble Masonry.

	No.	Length.	Breadth.	Depth.	Solid Feet.
1st Portion..............	1	17	8·70	2	295·80
2nd ditto	1	43	12·30	2	1,057·80
3rd ditto	1	20	8·86	2	354·40
Total solid feet uncoursed rubble masonry in the foundation					1,708·00

Building Dam of Coursed Rubble Masonry.

	No.	Length.	Breadth	Depth.	Solid Feet.
1st Portion..............	1	17	$\frac{6·70+5}{2}$	5·41	538·02
2nd ditto	1	43	$\frac{10·3+5}{2}$	10·30	3,388·18
3rd ditto	1	20	$\frac{6·86+5}{2}$	5·72	678·39
Total solid feet of coursed rubble masonry in superstructure					4,604·59

ABSTRACT.

Quantity.		Rs.	a.	p.
3,104	Solid feet excavating foundation in earth, at Rs. 0-4-0 per 100 solid feet........	7	12	1
1,057	Solid feet excavating foundation in soft rock, at Rs. 2 per 100 solid feet	21	2	2
1,708	Solid feet uncoursed rubble masonry in foundation, at Rs. 8 per 100 solid feet..	136	10	2
4,604	Solid feet of coursed rubble masonry in the superstructure, at Rs. 9-8-0 per 100 solid feet..........................	437	6	0
	Total ....Rs..	602	14	5
	Contingencies, at 5 per cent	30	2	3
	Total amount for the Ambeygaum Nullah dam ..Rs..	633	0	0

CONSTRUCTING MASONRY DAM ACROSS THE LAINDEE NULLAH.

Excavating Foundation in Earth.

	No.	Length.	Breadth.	Depth.	Solid Feet.
1st Portion from the left ..	1	23	11·83	$\frac{10·17+9·22}{2}$	2,637·91
2nd do. do. ..	1	16	11·83	$\frac{9·22+8·60}{2}$	1,686·48
3rd do. do. ..	1	11	11·83	$\frac{8·60+8·71}{2}$	1,126·27
4th do. do. ..	1	10	11·83	$\frac{8·71+8·59}{2}$	1,023·29
5th do. do. ..	1	14	11·83	$\frac{8·59+9·00}{2}$	1,456·62
6th do. do. ..	1	9	17·63	$\frac{18·46+15·69}{2}$	2,709·29
7th do. do. ..	1	17	17·63	$\frac{15·69+13·48}{2}$	4,371·27

CONSTRUCTING MASONRY DAM—(*continued*).

	No.	Length.	Breadth.	Depth.	Solid Feet.
8th Portion from the left ..	1	14	17·63	$\frac{13·48+10·00}{2}$	2,897·66
9th do. do. ..	1	9	17·63	$\frac{10·00+20·19}{2}$	2,395·12
10th do. do. ..	1	20	12·5	$\frac{11·19+11·33}{2}$	2,758·70
Total solid feet excavating foundation in earth					23,062·61

Building Foundations of Uncoursed Rubble Masonry.

	No.	Length.	Breadth.	Depth.	Solid Feet.
1st Portion	1	74	11·83	0·54	427·72
2nd do.	1	49	17·63	2·5	2,159·67
3rd do.	1	49	15·63	2·5	1,914·67
4th do.	1	49	13·63	2·5	1,669·67
5th do.	1	49	11·63	2·5	1,424·67
6th do.	1	20	12·5	0·62	151·90
Total solid feet uncoursed rubble masonry in the foundations					7,748·30

Building Dam of Coursed Rubble Masonry.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Building dam	1	143	$\frac{9·63+4·73}{2}$	9·63	9,901·27
Total solid feet coursed rubble masonry in superstructure.					9,901·27

ABSTRACT.

Quantity.		Rs.	a.	p.
23,062	Solid feet excavating foundation in earth, at Rs. 0-4-0 per 100 solid feet........	57	10	5
7,748	Solid feet uncoursed rubble masonry in the foundations, at Rs. 8 per 100 solid feet	619	13	5
9,901	Solid feet coursed rubble masonry in the superstructure at Rs. 9-8-0 per 100 solid feet	940	9	6
	Total....Rs..	1,618	1	4
	Contingencies, at 5 per cent.	80	14	5
	Total amount for the Laindee Nullah dam ..Rs..	1,698	0	0

MASONRY DAM ACROSS THE KONDWEH NULLAH.

Excavating Foundation in Moorum.

	No.	Length.	Breadth.	Depth.	Solid Feet.
1st Portion	1	8	15·56	$\frac{17·48+14·85}{2}$	2,012·21
2nd do.	1	5	15·56	14·85+4·00	733·26
3rd do.	1	14	15·56	$\frac{4·00+5·75}{2}$	1,061·97
4th do.	1	14	15·56	$\frac{·75+11·70}{2}$	1,900·65
5th do.	1	29	9·30	$\frac{5·0+7·11}{2}$	1,633·03

Total solid feet excavating foundation in moorum .... 7,341·12

Building Foundation of Uncoursed Rubble Masonry.

	No.	Length.	Breadth	Depth.	Solid Feet.
1st Portion	1	41	15·56	2	1,275·92
2nd ditto.	1	41	15·56	2	1,275·92
Total solid feet of uncoursed rubble masonry in the foundation					2,551·84

Building Dam of Coursed Rubble Masonry.

	No.	Length.	Breadth.	Depth.	Solid Feet.
1st Portion	1	41	$\frac{11·56+5·75}{2}$	11·56	4,102·12
2nd ditto.	1	29	$\frac{7·70+5·75}{2}$	7·11	1,386·62
Total solid feet of coursed rubble masonry in superstructure.					5,488·74

ABSTRACT.

Quantity.		Rs.	a.	p.
7,431	Solid feet excavating foundation in moorum, at Rs. 0-10-6 per 100 solid feet ..	48	2	9
2,551	Solid feet uncoursed rubble masonry in foundations, at Rs. 8 per 100 solid feet........	204	1	3
5,488	Solid feet coursed rubble masonry in superstructure, at Rs. 9-8-0 per 100 solid feet..............................	521	5	9
	Total....Rs..	773	9	9
	Contingencies, at 5 per cent..................	38	10	10
	Total amount for the Kondweh Nullah Dam ..Rs..	812	0	0

MASONRY DAM ACROSS THE NAHAVEE-DURRA NULLAH.

Excavating Foundation in Moorum.

	No.	Length.	Breadth.	Depth.	Solid Feet.
1st Portion	1	8	8·97	$\frac{8·97+5·19}{2}$	508·06
2nd do.	1	5	8·97	$\frac{5·19+4·0}{2}$	206·08
3rd do.	1	7	8·97	$\frac{4·0+6·08}{2}$	316·46
4th do.	1	4	8·97	$\frac{6·08+6·83}{2}$	231·60
5th do.	1	10	8·97	$\frac{6·83+7·48}{2}$	641·80
6th do.	1	10	6·97	$\frac{4·0+5·49}{2}$	330·72
Total solid feet excavating foundation in moorum					2,234·72

Building Foundation of Uncoursed Rubble Masonry.

	No.	Length.	Breadth.	Depth.	Solid Feet.
1st Portion..............	1	34	8·97	2	609·96
2nd do.	1	10	8·97	2	179·40
3rd do.	1	10	6·97	0·52	36·24
Total solid feet uncoursed rubble masonry in foundation..					825·60

Building Dam of Coursed Rubble Masonry.

	No.	Length.	Breadth.	Depth.	Solid Feet.
1st Portion..............	1	34	$\frac{4·07+2·5}{2}$	4·97	631·14
2nd ditto	1	10	$\frac{4·07+2·5}{2}$	4·97	185·62
Total solid feet coursed rubble masonry in superstructure.					816·76

ABSTRACT.

Quantity.		Rs.	a.	p.
2,234	Solid feet excavating foundation in moorum, at Rs. 0-10-6 per 100 solid feet ..	14	10	6
825	Solid feet of uncoursed rubble masonry in foundation, at Rs. 8 per 100 solid feet............................	66	0	0
816	Solid feet of coursed rubble masonry in superstructure, at Rs. 9-8-0 per 100 solid feet............................	77	8	3
	Total....Rs..	158	2	9
	Contingencies, at 5 per cent..................	7	14	6
	Total amount for the Nahavee-Durra Nullah ....Rs..	166	1	3

RECAPITULATION.

		Rs.	a.	p.
Amount for excavating the cut to carry off the first floods..		21,342	0	0
do.	Ambeygaum Nullah dam	633	0	0
do.	Laindee Nullah dam	1,698	0	0
do.	Kondweh Nullah dam	812	0	0
do.	Nahavee-Durra Nullah dam	166	0	0
	Grand total for the artificial cut ......Rs..	24,651	0	0

No. 4.—INLET TOWER.

Excavating the Foundation for the Tower.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Excavating foundation of tower	1	33	33	13	14,157
Total solid feet excavating foundation in sand, gravel, and water					14,157

Coursed Rubble Masonry in Foundation.

	No.	Length.	Breadth	Depth.	Solid Feet.	Solid Feet.
1st portion from the base of the tower	1	33	33	2	2,178·00	
2nd do. do..	1	31^2	·7854	1	754·76	
3rd do. do..	1	30^2	·7854	1	706·86	
4th do. do..	1	29^2	·7854	1	660·52	
5th do. do..	1	28^2	·7854	1	615·75	
6th do. do..	1	27^2	·7854	1	572·55	
7th do. do..	1	26^2	·7854	1	530·93	
8th do. do..	1	25^2	·7854	1	490·87	
9th do. do..	1	24^2	·7854	1	452·39	
Total..	..	....	....	....	......	6,962·63
DEDUCT.						
Semisphere inverted.	1	18^3	$\frac{\cdot 5236}{2}$		1,526·81	
Portion of iron tube occupying the space	1	$\frac{8\cdot 5+4\cdot 5}{2}$	3^2	·7854	45·95	
Total deductions ..	..	....	....	....	......	1,572·76
Total solid feet coursed rubble masonry in the foundation of the tower						5,389·87

Circular Invert on which the Tower rests.

	No.	Diameter	Breadth.	Depth.	Solid Feet.	Solid Feet.
Taking the outer surface of the circular invert	1	18^3	$\frac{\cdot 5236}{2}$	....	1526·81	
Total..	..	....	....	....	.....	1526·81
DEDUCT.						
Semispherical portion	1	13^3	$\frac{\cdot 5236}{2}$	....	575·17	
Portion occupied by tube	1	$\frac{2\cdot 5+4}{2}$	3^2	·7854	22·97	
Total deductions ..	..	....	....	....	......	598·14
Total solid feet in semispherical invert of roughly-dressed stone and lime						928·67

Domed Floor on which the Steps rest, over the Filter.

	No.	Length.	Breadth.	Depth.	Solid Feet.	Solid Feet.
Taken as a solid mass.	1	13^2	·7854	2·75	356·01	
Total..	..	....	....	....	......	356·01
DEDUCT.						
Segmental portion .	1	$\overline{13\times 3 - 1\cdot 25\times 2}\times 1\cdot 25^2\times 5236=$				29·86
Total solid feet in domed stone floor of cut-stone masonry..						326·15

Walls of Tower.

	No.	Length.	Breadth.	Height.	Solid Feet.
Walls of tower	1	$\frac{56\cdot5488+50\cdot2656}{2}$	$\frac{5+3}{2}$	60	12,816·52
Total solid feet cut-stone masonry					12,816·52

Steps in the Inside of Tower.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Steps	44	2	1	1	44
No. of cut-stone steps in the interior of the tower					44

Filling in with Dry Stone the Base of the Tower, used as a Filter.

	No.	Length.	Breadth	Depth.	Solid Feet.
1st portion	1	13^3	$\frac{\cdot5236}{2}$	....	575·17
2nd ditto	1	13^2	·7854	1·25	165·91
Total solid feet filling in with dry stone (amygdaloid)....					741·08

Filling in Fine and Coarse Sand to Filter.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Base of tower (coarse sand) ..	1	13^2	·7854	5·75	763·21
Upper part (fine sand)...	1	13^2	·7854	5·25	696·84
Do. (do.) ...	1	$13 \times 3 - \overline{1\cdot25 \times 2} \times \overline{1\cdot25} \times \cdot5236$			29·86
Total solid feet filling in sand to the filter					1,489·91

Cornice to Tower at Top.

	No.	Diameter.	Running Feet.
Cornice of inlet tower	19	3·1416	59·69
Total running feet of cornice at top of tower			59·69

Portion of Tower above Cornice.

	No.	Length.	Breadth.	Depth.	Solid Feet.	Solid Feet.
Wall	1	17·5 × 3·1416 × 1·5 × 10·42			859·30	859·30
DEDUCT OPENINGS.						
Doors, rectangular parts	3	4	1·5	6	108·0	
,, circular parts .	3	Area 6·2832		1·5	28·27	
Large door, rectangular part.	1	8	1·5	4	48·0	
,, circular part . .	1	Area 25·1328		1·5	37·69	
Total deductions.	..	....	....	....	......	221·96
Total solid feet coursed rubble masonry in circular portion of tower above the cornice						637·34

Roof of Tower.

	No.	Slant Height.	Perimeter.	Square Feet.
Roof	1	12·69	22 × 3·1416	438·53
	∴	$\frac{22 \times 3{\cdot}1416 \times 12{\cdot}69}{2}$		
Total square feet of double tiled teak-wood roof				438·53

Iron Work.

	No.	Length.	Diameter.
Tube taken ten feet outside the base of the tower	1	86·5	3′
Pipes by which the water from the reservoir enters the bottom of the tower	8	each 20	1′
Tubes in the walls of the tower, eight in number, in the circumference at each length	72	average 5	
Gratings, eight in number, seven of 1 foot in diameter, and one of 3 feet in diameter	8	..	7 of 1 foot 1 of 3 feet

ABSTRACT.

Quantities.		Rs.	a.	p.
14,157	Solid feet excavating foundation in sand, gravel, and water, at Rs. 2-8-0 per 100 solid feet	353	14	9
5,389	Solid feet of coursed rubble masonry in foundation of tower, at Rs. 9-8-0 per 100 solid feet	511	15	3
928	Solid feet of roughly-dressed stone and lime in semispherical invert at Rs. 30 per 100 solid feet	278	6	4
326	Solid feet of cut-stone masonry in domed stone floor, at Rs. 0-9-0 per 100 solid feet..............................	183	6	0

ABSTRACT—(*continued*).

Quantities.		Rs.	a.	p.
12,816	Solid feet of cut-stone masonry in walls of tower, at Rs. 45 per 100 solid feet (coursed rubble masonry faced with cut-stone on both sides)	5,767	3	2
44	Number of cut-stone steps in the interior of the tower, at Rs. 2-4-0 per step	99	0	0
741	Solid feet filling in with dry stone, to the base of the tower, at Rs. 2-8-0 per 100 solid feet	18	8	4
1,489	Solid feet filling in with fine and coarse sand to the base of the tower, at Rs. 4-8-0 per 100 solid feet	67	0	0
59½	Running feet of cornice round the top of the tower, at Rs. 5-6-0 per foot	319	13	0
637	Solid feet of coursed rubble masonry in wall of circular portion above the cornice, at Rs. 9-8-0 per 100 solid feet	60	8	2
438	Square feet of roofing of double tiles, teak-wood cut battens, and teak-wood cut rafters, at Rs. 29-8-0 per 100 square feet	129	3	4
1	Iron tube, 86½ feet long, running down the centre of the tower	2,448	13	10
8	Iron pipes by which the water from the reservoir enters the bottom of the tower	712	11	0
72	Iron tubes in the walls of the tower	611	12	4

ABSTRACT—(*continued*).

Quantities.		Rs. a. p.
7	Iron gratings, 1 foot diameter, at Rs. 3 each	21 0 0
1	Iron grating, 3 feet diameter, at Rs. 10 each	10 0 0
	Total .. ..Rs..	11,593 3 2
	Contingencies, at 5 per cent....................	579 10 6
	Total amount for inlet tower........Rs..	12,172 0 0

No. 5.—GANGWAY.

Excavating Foundation.

	No.	Length.	Breadth.	Depth.	Solid Feet.
For pier..................	1	22	16	10	3,520
Total solid feet excavating foundation in sand, gravel, and water..............................					3,520

Filling in Foundation of Uncoursed Rubble Masonry.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Abutment in embankment, off-set of	1	13	7·0	1	91
Do. do.	1	11	5·0	1	55
Centre pier, 1st offset	1	22	16	2	704
Do. upper offset	1	$\frac{0+13}{2}$	$\frac{14+7}{2}$	8	173·25
Total solid feet filling in foundations of uncoursed rubble masonry					1,023·25

Superstructure of Piers and Abutment.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Centre pier, portion over footings	1	12	6	19·5	1,423·5
Do. middle do..	1	11	5	20 0	1,100·0
Do. upper do..	1	10	4	17·0	680·0
Abutment in embankment ..	1	10	4	12·0	480·0
Total solid feet in superstructure in pier and abutment of coursed rubble masonry					3,683·5

WOODWORK.

(The whole Framing taken.)

TEAKWOOD.

	No.	Length.	Breadth	Thickness.	Solid Feet.
Lower chord pieces (taken as one beam)..........	2	180′	14″	10″	350·00
Upper do. (do)	2	180′	15″	$7\frac{1}{2}$″	281·25
Main braces	96	$9\frac{3}{4}$′	$5\frac{1}{2}$″	5″	178·75
Counter braces	48	$9\frac{3}{4}$′	5″	5″	81·25
Lateral braces	46	9′	8″	3″	69·00
Caps on pier	2	$8\frac{3}{4}$′	14″	10″	17·01
Ditto.	2	$11\frac{3}{4}$′	14″	10″	22·84
Caps on tower and abutment in embankment ..	4	$11\frac{3}{4}$′	14″	10″	45·69
Struts	4	11′	14″	6″	25·66
Planking	1	180′	8″	$3\frac{1}{2}$″	420·00
End panels, posts	16	$7\frac{1}{4}$′	5″	6″	24·16
Do. counter braces..	4	$7\frac{1}{4}$″	5″	5″	5·03

WOODWORK—(*continued*).

	No.	Length.	Breadth.	Thickness.	Solid Feet.
End panels, main braces ..	8	$7\frac{1}{4}'$	$5\frac{1}{2}''$	$5''$	11·07
Do. pieces to receive the feet of ditto......	4	$3\frac{3}{3}'$	$14''$	$4''$	5·70
Side planking	2	$180'$	$9''$	$2''$	45·00
Solid feet	..	....	....	......	1,582·41
Add $\frac{1}{5}$th for wastage......	..	....	....	......	316·48
Total teak-wood, solid feet.	..	....	....	......	1,898·89
BABOOL WOOD.					
Tongues between timbers of lower chord	72	$6''$	$2\frac{1}{2}''$	$10''$	6·25
Tongues between timbers of upper chord	104	$6''$	$2\frac{1}{2}''$	$7\frac{1}{2}''$	6·77
Lower chord, pieces at joints of timbers	68	$4'$	$3''$	$10''$	56·66
Solid feet..........................					69·68
Add $\frac{1}{5}$th for wastage					13·93
Total babool-wood solid feet					83·61

IRON WORK.

Castings.

	No.	Length.	Breadth.	Depth.	Pounds Avoirdupois.
Lower chord angle blocks, each 45 lbs..................	46	$16''$	$7\frac{1}{2}'$	$14\frac{1}{8}''$	2,070·00
Upper chord angle blocks, each 40 lbs...................	66	$16''$	$7\frac{1}{2}''$	$11\frac{5}{8}''$	1,840·00
Total lbs. of iron castings..............					3,910·00

Wrought Iron (round).

	No.	Length.	Total Length in Feet.	Size.	Tabular Number.	Ounces Avoirdupois.
Lateral brace bolts	24	8½′	204′	dia. 1″	41·740	8,514·96
Bolts for chord pieces (lower chord)	104	1′7″	164·66	dia. ½″	10·435	1,703·40
Bolts for chord pieces (upper chord)	104	1′7″	164·66	dia. ½″	10·435	1,703·40
Suspension bolts between chords......	100	8½′	850′	dia. 1″	41·740	35,479·00
At the intersection of main and counter braces	52	1′7″	82·33	dia. ½″	10·435	859·11
Flat.						
Nuts for lateral brace bolts	48	2″	8′	2″×1½″	159·436	1,275·48
Nuts for bolts to upper and lower chords ..	208	1½″	26′	1½″×1″	79·718	2,072·66
Nuts for suspension bolts.	200	2″	33′33	2″×1½″	159·436	5,314·00
Nuts at the intersection of main and counter braces	52	1½″	6′5	1½″×1″	79·718	518·16
Iron plates at top and bottom of suspension bolts	100	16″	133′33	3½″×½″	93·004	12,400·22
Washers	284	2½″	59·16	2½″×¼″	33·216	1,965·05
Total weight in ounces						71,805·44
Total lbs. of wrought-iron work......................						4,487·00

Spikes and Nails.

	No.	Length.	Pounds.
5-inch spikes	900	5″	60·00
Nails of sorts	500	Sorts.	40·00
Total lbs. weight of spikes and nails....			100·00

Labour.

	Days.	Total Days.
Carpenters, 1st sort	450	450
Do. 2nd sort	850	850
Labourers under do.	1750	1750

Scaffolding.

	Number.
Scaffolding (360 running feet)	1
Total No. of scaffolding................	1

ABSTRACT.

Quantities.		Rs.	a.	p.
3,520	Solid feet excavating foundation in sand, gravel, and water, at Rs. 2-8-0 per 100 solid feet	88	0	0
1,023	Solid feet filling in foundation of uncoursed rubble masonry, at Rs. 8 per 100 solid feet	81	13	5
3,683	Solid feet in superstructure of pier and abutment of coursed rubble masonry, at Rs. 15 per 100 solid feet	552	7	2
1,898	Solid feet of teak-wood in woodwork, at Rs. 2-15-2 per foot	5,595	2	4

ABSTRACT—(*continued*).

Quantities.		Rs.	a.	p.
83	Solid feet of babool-wood in woodwork, at Rs. 0-12-0 per foot	62	4	0
3,910	Pounds of iron castings at Rs. 13-2-9 per cwt..........................	459	13	5
4,487	Pounds of wrought-iron in bolts, nuts, washers, &c., at Rs. 6 per 28 lbs. ...	961	8	0
100	Pounds of spikes and nails of sorts, at Rs. 1 per 7 lbs.....................	14	4	6
450	Days carpenters' hire, at Rs. 0-8-0 per day.	225	0	0
850	Days do. at Rs. 0-6-0 per day.	318	12	0
1,750	Days labourers' hire at Rs. 0-2-0 per day.	218	12	0
1	Scaffolding	72	0	0
	Total ....Rs...	8,649	12	10
	Add contingencies, at 5 per cent.........	432	7	10
	Total amount for gangway ....Rs..	9,082	0	0

No. 6.—MASONRY AQUEDUCT MEASUREMENTS.

Excavating Trench for the Aqueduct.

	No.	Length.	Breadth.	Depth.	Solid Feet.
For that portion of the aqueduct, from the inlet tower to the mouth of the tunnel, on the Ambeygaum side....	..	....	....	....	8,05,510

MASONRY AQUEDUCT, &c.—(*continued.*)

	No.	Length.	Breadth.	Depth.	Solid Feet.
For that portion of the aqueduct from the chambered shaft No. 1 to the distribution reservoir in the camp	.	....	....	....	7,57,231
Total solid feet excavating trench for the masonry aqueduct					15,62,741
1-5th do. taken in soft rock					3,12,548
4-5ths do. taken in moorum					12,50,193
Total solid feet......					15,62,741

Excavation for the Air-Shafts of the Aqueduct.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Air-shafts	66	6·5	6·5		5,577
Total solid excavation for the air-shafts of the aqueduct ..					5,577
1-5th do. taken in soft rock					1,115·4
4-5ths do. taken in moorum					4,461·6
Total solid feet					5,577·0

Building Aqueduct, Interior Measurement 18 × 15 *inches, slab-top.*

	No.	Length.	Breadth.	Depth.	Solid Feet.
Total length........ Feet 34,367·5					
DEDUCT :—					
Portion under the embankment...... Feet 335·0					
Raised portion.. „ 1,147·5					
Portions included in the air-shafts.. „ 396·0					
1,878·5					
32,489·0					
Sill of aqueduct..........	1	32,489	4	1	1,29;956·0
Sides of do.	2	32,489	1	1·25	81,222·5
Top of do.	1	32,489	3½	1	1,13,711·5
Sills of air-shafts..........	66	6·5	6·5	1	2,788·5
Superstructure of air-shafts ..	66	Four sides. 18	1½	8	14,256·0
Total solid feet building aqueduct of coursed rubble masonry, interior measurement 18 × 15 inches					3,41,934·5

Covering Mouths of Air-Shafts with Stone Slabs set in Lime.

	No.	Length.	Breadth.	Depth.	Square Feet.
Mouths of air-shafts........	66	4	4	6″	1,056
Total square feet of covering mouths of air-shafts with stone slabs set in lime............					1,056

Building Aqueduct, Interior Measurement 15″ × 18″. Portion passing under the Embankment.

	No.	Length.	Breadth.	Depth.	Solid Feet.	Total Solid Feet.
Filling in foundation	1	335	4	1	1,340·0	
Superstructure, taken as a whole ..	1	335	$3\frac{1}{2}$	3	3,517·5	4,857·5
DEDUCT :—						
Open portion of aqueduct	1	335	1·5	1·25	628·125	
Do. do:	1	335	$\frac{1{\cdot}5^2 \times {\cdot}7854}{2}$		295·997	924·12
Total solid feet of coursed rubble masonry in building that portion of the aqueduct passing under the embankment, with an arched head						3,933·38

Raising a Portion of the Aqueduct near the Distribution Reservoir.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Excavating foundation	1	1,147·5	4·5	1·5	7,745·62
Total solid feet excavating foundation in moorum					7,745·62

Building Raised Portion of Coursed Rubble Masonry.

	No.	Length.	Breadth	Depth.	Solid Feet.
Foundation, same as excavation above					7,745·62
1st portion		46	4	$\frac{4{\cdot}40}{2}$	404·80
2nd do.		50	4	$4{\cdot}40+8{\cdot}86$	1,326·00
3rd do.		50	4	$\frac{8{\cdot}72+8{\cdot}86}{2}$	1,758·00
4th do.		100	4	$\frac{11{\cdot}18+8{\cdot}72}{2}$	3,980·00
5th do.		130	4	$15{\cdot}05+11{\cdot}18$	7,053·80
6th do.		53	4	$\frac{13{\cdot}78+15{\cdot}05}{2}$	3,151·38
7th do.		95	4	$\frac{7{\cdot}50+13{\cdot}78}{2}$	4,043·20
8th do.		$52\frac{1}{2}$	4	$\frac{2\ 25+7{\cdot}50}{2}$	·1,023·75
9th do.		97	4	$\frac{2{\cdot}42+2{\cdot}25}{2}$	905·98
10th do.		93	4	$\frac{6{\cdot}46+2{\cdot}42}{2}$	1,651·68
11th do.		32	4	$\frac{6{\cdot}40+6{\cdot}46}{2}$	823·04
12th do.		50	4	$\frac{5{\cdot}34+6{\cdot}40}{2}$	1,174·00
13th do.		50	4	$\frac{6{\cdot}72+5{\cdot}34}{2}$	1,206·00
14th do.		46	4	$\frac{11{\cdot}13+6{\cdot}72}{2}$	1,642·20
15th do.		54	4	$\frac{11{\cdot}13+13{\cdot}57}{2}$	2,667·60
16th do.		44	4	$\frac{9{\cdot}19+13{\cdot}57}{2}$	2,002·88
17th do.		56	4	$\frac{6{\cdot}14+9{\cdot}19}{2}$	1,716·96
18th do.		49	4	$\frac{2{\cdot}25+6{\cdot}14}{2}$	822·22
Total solid feet					45,099·11
Deduct,—opening of aqueduct		1,147·5	1·5	1·25	2,151·56
Total solid feet coursed rubble masonry in raising aqueduct					42,947·55

Filling in Trench over Aqueduct.

	Area.	Solid Feet.
Solid feet of excavation in trench as above	....	15,62,741
Deduct,—solid feet of masonry work of the aqueduct, taken as area	$\overline{4 \times 3\frac{1}{4}} \times 32,489$	4,22,357
Total solid feet..........		11,40,384
Half do.		5,70,192
Solid feet of half filling into trench		5,70,192

ABSTRACT.

Quantities.		Rs.	a.	p.
3,12,548	Solid feet of excavating trench for masonry aqueduct in soft rock, at Rs. 2 per 100 solid feet	6,250	15	4
12,50,193	Solid feet of excavating trench for masonry aqueduct in moorum, at Rs. 0-10-6 per 100 solid feet	8,204	6	3
1,115	Solid feet of excavating bottoms of air-shafts in soft rock, at Rs. 2 per 100 solid feet	22	4	9
4,461	Solid feet of excavating bottoms of air-shafts in moorum, at Rs. 0-10-6 per 100 solid feet	29	4	4
3,41,934	Solid feet of building aqueduct of coursed rubble masonry (18 × 15 inches interior measurement), at Rs. 10-8-0 per 100 solid feet	35,903	1	1

ABSTRACT—(*continued*).

Quantities.		Rs.	a.	p.
1,056	Square feet covering mouths of air-shafts with slab stones set in lime, at Rs. 15-10-0 per 100 square feet	165	0	0
3,933	Solid feet of building aqueduct of coursed rubble masonry (18″ × 15″ inches interior measurement, arched head), being the portion passing under the embankment, at Rs. 10-8-0 per 100 solid feet..	412	15	5
7,745	Solid feet excavating foundation in moorum for the raised portion of the aqueduct, at Rs. 0-10-6 per 100 solid feet..	50	13	2
42,947	Solid feet building raised portion of the aqueduct of coursed rubble masonry, at Rs. 10-8-0 per 100 solid feet	4,509	6	11
5,70,192	Solid feet filling in trench over aqueduct, at Rs. 0-1-6 per 100 solid feet	534	8	10
	Total .... Rs.	56,082	12	1
	Contingencies, at 5 per cent.	2,804	2	2
	Total amount for portion of masonry aqueduct 15″ × 18″ inches interior measurement ..Rs...	58,886	0	0

TUNNEL.

Excavation.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Shaft at the mouth of the tunnel on the Ambeygaum side, No. 8 of Plan No. 7.....		14	14	61	11,956·00

TUNNEL—(*continued*).

Excavation.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Air-shaft of tunnel, No. 7 of Plan No, 7, 1st portion ..	1	dia. 8^2	·7854	20	1,005·31
Do. 2nd do. ..	1	4^2	·7854	83	1,043·01
Air-shaft of tunnel, No. 6 of Plan No. 7, 1st portion ..	1	8^2	·7854	20	1,005·31
Do. 2nd do. ..	1	4^2	·7854	74·5	936·19
Shaft at the mouth of the tunnel on the Duncowree side, No. 5 of Plan No. 7......	1	14·5	14·5	65·75	13,823·93
Tunnel. Portion revetted for a length of 20 feet from the mouths at each end. Fig. 3 of Plan No. 7	2	20	area 39·38	60,962·77	1,575·20
Tunnel. Portion unrevetted. Fig. 2 Plan No. 7 $(2{,}781\frac{1}{2} - \overbrace{(14+14\frac{1}{2})}^{\text{Two shafts.}} - \overbrace{20-20}^{\text{Two revetted parts.}}) = 2713$..	1	2713	area 21·89		59,387·57

Total solid feet excavation for tunnel .... 90,732·52

Total solid feet excavating tunnel in rock..............	60,962·77
Total solid feet excavating shafts to tunnel in rock (1-3rd of the rest)	9,923·25
Total solid feet do. in hard moorum (2-3rds of the rest) ...	19,846·50
Total solid feet........	90,732·52

Coursed Rubble Masonry in Entrance and Air-Shafts and Revetment to Mouths of Tunnel for a Length of 20 Feet.

	No.	Lengt	Breadth.	Depth.	Solid Feet.
Entrance to tunnel. Shaft on the Ambeygaum side. No. 8 of Plan No. 7. 1st portion . .	1	36			900·00
2nd portion	1	35	4·75		831·25
3rd do.	1	34	4 5		765·00
4th do.	1	33	4·25		701·25
5th do.	1	32	4·0		640·00
6th do.	1	31	3·75		581·25
7th do.	1	30	3·5		525·00
8th do.	1	29	3·25		471·25
9th do.	1	28	3·0		420·00
10th do.	1	27	2·75		371·25
11th do.	1	26	2·5		325·00
12th do.	1	25	2·25	6	337·50
13th do.	1	24	2·0	4	192·00
Entrance to tunnel. Shaft on the Duncowree side. No. 5 of Plan No. 7. 1st portion . .	1	37			971·25
2nd portion	1	36	5·0		900·00
3rd do.	1	35	4·75		831·25
4th do.	1	34	4·5		765·00
5th do.	1	33	4·25		701·25
6th do.	1	32	4·0		640·00
7th do.	1	31	3·75		581·25
8th do.	1	30	3·5		525·00
9th do.	1	29	3·25		471·25
10th do.	1	28	3·0		420·00
11th do.	1	27	2·75		371·25

Coursed Rubble Masonry in Entrance, &c.—(continued.)

	No.	Length.	Breadth.	Depth.	Solid Feet.
12th portion	1	26	2·5	5	325·00
13th do.	1	25	2·25	4·75	267·18
14th do.	1	24	2·0	4·0	192·00
Revetting mouths of tunnel ..	2	20	areas 39·38 21·89 17·49		699·60
Masonry work to the mouths of air-shafts, Nos. 6 and 7 of Plan No. 7	2	18·849	2	24	1,809·50
Total solid feet of coursed rubble masonry in entrance and air-shafts to tunnel, and revetting tunnel for a distance on each side of 20 feet					17,531·53

Doors to Shafts.

	No.
Doors of teak-wood plank batten	4
Total No. of teak-wood plank batten doors to shafts..	4

ABSTRACT.

Quantities.		Rs.	a.	p.
60,962	Solid feet excavating tunnel in rock, at Rs. 12 per 100 solid feet	7,315	7	0
9,923	Solid feet excavating entrance and air-shafts to tunnel in rock, at Rs. 4 per 100 solid feet	396	14	8

ABSTRACT—(*continued*).

Quantities.		Rs. a. p.
19,846	Solid feet excavating entrance and air-shafts to tunnel in hard moorum, at Rs. 0-14-0 per 100 solid feet	173 10 5
17,531	Solid feet of coursed rubble masonry in entrance and air-shafts to tunnel, and the revetment to the tunnel for a length of 20 feet at each mouth, at Rs. 15 per 100 solid feet	2,629 10 4
4	No. of doors to mouths of shafts of teak-wood plank batten, at Rs. 16 each door	64 0 0
	Total....Rs....	10,579 10 5
	Contingencies, at 5 per cent................	528 15 8
	Total amount for tunnel ....Rs....	11,108 0 0

Masonry Aqueduct $4\frac{1}{2}' \times 3'$ Interior Measurement, with Arched Head.

MEASUREMENTS.

Excavation of Trench for Aqueduct.

	No.	Length.	Breadth.	Depth.	Solid Feet.
For that portion of the aqueduct from the mouth of the tunnel on the Duncowree side to the first chambered shaft, that is, between Nos. 1 and 5 of Plan No. 8.. ...	.	....	....	....	21,56,874
Solid feet of excavating trench for aqueduct....					21,56,874

Masonry Aqueduct $4\frac{1}{2}' \times 3'$—*(continued)*.

			Solid Feet.
1-10th	solid feet of excavation	taken in rock	2,15,687
1-10th	do.	taken in soft rock	2,15,687
4-5ths	do.	taken in moorum	17,25,500
		Total solid feet..	21,56,874

Excavating Bottom of Chambered Shafts, below Sill of Aqueduct.

	No.	Length.	Breadth.	Depth.	Solid Feet.
No. 4 of Plan No. 7........	1	16	10·5	2	336·00
No. 3 of do.	1	15·5	10·5	2	310·00
No. 2 of do.	1	14·5	9·5	2	275·50
No. 1 of do.	1	13·5	8·5	2	229·50
Total solid feet of excavation in rock for bottoms of chambered shafts, below the sill of the aqueduct					1,151·00

Building Chambered Shafts Nos. 1, 2, 3, *and* 4, *of Coursed Rubble Masonry faced with Cut-Stone.*

	No.	Length.	Breadth.	Depth.	Solid Feet.
No. 4 of Plan No. 7. Foundation	1	16	10·5	1	168·00
1st portion of side walls above foundation.............	1	37	3·5	5	647·50

Building Chambered Shafts, &c.—(continued.)

	No.	Length.	Breadth.	Depth.	Solid Feet.
2nd portion of side walls, &c.	1	36	3·25	5	585·00
3rd do. do.	1	35	3·0	5	525·00
4th do. do.	1	34	2·75	5	467·50
5th do. do.	1	33	2·5	5	412·50
6th do. do.	1	32	2·25	5	360·00
7th do. do.	1	31	2·0	3	186·00
Division wall	1	3	2·5	33	247·50
No. 3 of Plan No. 7. Foundation	1	15·5	10·0	1	155·00
1st portion of side walls above foundation..............	1	36	3·25	5	585·00
2nd do. do.	1	35	3·0	5	525·00
3rd do. do.	1	34	2·75	5	467·50
4th do. do.	1	33	2·5	5	412·50
5th do. do.	1	32	2·25	5	360·00
6th do. do.	1	31	2·0	5	310·00
Division wall..............	1	3	2·5	30	225·00
No. 2 of Plan No. 7. Foundation	1	14·5	9·5	1	137·75
1st portion of side walls above foundation	1	34	3·0	5	510·00
2nd do. do.	1	33	2·75	5	453·75
3rd do. do.	1	32	2·5	5	400·00
4th do. do.	1	31	2·25	3·75	261·56
5th do. do.	1	30	2·0	3·0	180·00
Division wall	1	3	2·5	21·75	163·12
No. 1 of Plan No. 7. Foundation	1	13·5	8·5	1	114·75
1st portion of side walls above foundation..............	1	32	2·5	5	400·00

Building Chambered Shafts, &c.—(continued.)

	No.	Length.	Breadth	Depth.	Solid Feet.
2nd portion of side walls, &c.	1	31	2·25	5	348·75
3rd do. do.	1	30	2·0	4	240·00
Division wall	1	2	3	14	84·0
Total solid feet of coursed rubble masonry, faced with cut-stone to four chambered shafts..........					9,932·68

Building Aqueduct, Arched Head Interior Measurement $3' \times 4\frac{1}{2}'$.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Foundation, total length 3,967. Deduct spaces occupied by chambered shafts Nos. 1, 2, 3, and 4 = 12·75 + 13·75 + 14·75 + 15·25 = 3,967—56·5 = 3,910·5	1	3,910·5	6·5	1	25,418·25
Side walls	2	3,190·5	1·5	3	35,194·50
Arching................	1	3,910·5	length of arc 6·283	1	24,569·67
Backing to arching	2	3,910·5	area 1·5	..	11,731·5
Total solid feet of coursed rubble masonry, including arched head in aqueduct $3' \times 4\frac{1}{2}'$ interior measurement					96,913·92

Filling in Trench over Aqueduct.

	No.	Length.	Breadth.	Depth.	Solid Feet.	Total Solid Feet.
Solid feet of excavation, as above	..	....	....	....	21,56,874	21,56,874·0

Filling in Trench over Aqueduct—(continued).

	No.	Length.	Breadth.	Depth.	Solid Feet.	Total Solid Feet.
Brought forward ...	..	....	....	....	......	21,56,874·0
DEDUCT :—						
Solid feet of masonry work of the aqueduct. (Taken as a rectangle).	1	3,910·5	area 39		1,52,509·5	
Do. do. No. 1 chambered shaft	1	13	8	9·	936·0	
Do. do. No. 2 do....	1	14	9	17·75	2,236·5	
Do. do. No. 3 do....	1	15	9·5	19·	2,707·5	
Do. do. No. 4 do....	1	15	10	29·	4,350·0	
						1,62,739·5
					Total solid feet...	19,94,134·5
					Half do.	9,97,067·25
Total solid feet of half-filling in trench over aqueduct....						9,97,067·25

Doors.

	No.
Doors of teak-wood plank batten 3′ × 3′	8
Total No. teak-wood plank batten doors 3′ × 3′	8

ABSTRACT.

Quantities.		Rs.	a.	p.
2,15,687	Solid feet excavating trench for aqueduct in rock, at Rs. 4 per 100 solid feet	8,627	7	8
2,15,687	Solid feet excavating trench for aqueduct in soft rock, at Rs. 2 per 100 solid feet.	4,313	11	10

ABSTRACT—(*continued*).

Quantities.		Rs.	a.	p.
17,25,500	Solid feet excavating trench for aqueduct in moorum, at Rs. 0-10-6 per 100 solid feet	11,323	9	6
1,151	Solid feet of excavating bottoms of chambered shafts below the sill of the aqueduct in rock, at Rs. 4 per 100 solid feet	46	0	7
9,932	Solid feet of coursed rubble masonry faced with cut-stone in chambered shafts, at Rs. 30 per 100 solid feet..	2,979	9	7
96,913	Solid feet of building aqueduct (3′ × $4\frac{1}{2}$′ arched head) of coursed rubble masonry, at Rs. 15 per 100 solid feet ..	14,536	15	2
9,97,067	Solid feet filling in trench over aqueduct, at Rs. 0-1-6 per 100 solid feet ..	934	12	0
8	No. of teak-wood plank batten doors 3′ × 3′, at Rs. 9 each	72	0	0
	Total....Rs..	42,834	2	4
	Contingencies, at 5 per cent....	2,141	11	3
	Total amount for aqueduct with head of arched masonry...........................	44,975	0	0

RECAPITULATION.

	Rs.	a.	p.
Total amount for the portion of masonry aqueduct; rectangular section 18″×15″ interior measurement, including that passing under the embankment	58,886	0	0

RECAPITULATION—(*continued*).

	Rs.	a.	p.
Total amount of tunnel	1[illegible]108	0	0
Total amount for the portion of the masonry aqueduct, circular head $4\frac{1}{2} \times 3$ feet interior measurement..............................	44,975	0	0
Total amount for the masonry aqueduct, including tunnel	1,14,969	0	0

IRON CONDUIT PIPE 13 INCHES DIAMETER.

MEASUREMENTS.

Excavating the Trench for the Iron Conduit Pipe.

	No.	Length.	Breadth.	Depth.	Solid Feet.
For the whole portion of the trench, from the inlet tower to the distribution reservoir in the camp, excepting that portion occupied by the tunnel ..	..	....	...	....	26,43,179
Total solid feet of excavating trench for the iron conduit pipe					26,43,179
1-10th solid feet of excavation taken in rock					2,64,317·5
1-10th do. do. taken in soft rock......					2,64,317·5
4-5ths do. do. taken in moorum......					21,14,544·0
Total solid feet....					26,43,179

Building Chambered Shaft No. 3 of Plans 7 and 8.
Excavating Foundation.

	No.	Length.	Area.	Solid Feet.
No. 3 chambered shaft	1	15·5	430·5	6,672·75
Deduct:—Portion included in the trench	1	15·5	262·5	4,068·75
Total solid feet excavating for the foundation of No. 3 chambered shaft				2,604·0

1-10th solid feet excavation taken in rock	260·4
1-10th do. do. taken in soft rock	260·4
4-5ths do. do. taken in moorum	2,083·2
Total solid feet....	2,604·0

Coursed Rubble Masonry faced with Cut-Stone in No. 3, as above.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Foundation	1	15·5	10	1	155·0
1st portion of side walls above foundation...............	1	36	3·25	5	585·0
2nd do. do.	1	35	3·0	5	525·0
3rd do. do.	1	34	2·75	5	467·5
4th do. do.	1	33	2·5	5	412·5
5th do. do.	1	32	2·25	5	360·0
6th do. do.	1	31	2·0	5	310·0
Division wall	1	3	2·5	30	225·0
Total solid feet coursed rubble masonry faced with cut-stone in chambered shaft No. 3					3,040·0

Iron Pipe 13 *Inches Diameter.*

	Length.	Running Feet.
Iron conduit pipe 13 inches diameter	27,343	27,343
Total running feet iron conduit pipe 13 inches diameter		27,343

Filling in Trench over Pipe.

	Solid Feet.
Same as excavating	26,43,179
Total solid feet filling in trench over iron conduit pipe.	26,43,179

ABSTRACT.

Quantities.		Rs.	a.	p.
2,64,317	Solid feet excavating trench for iron conduit pipe in rock, at Rs. 4 per 100 solid feet	10,572	10	10
2,64,317	Solid feet excavating trench for iron conduit pipe in soft rock, at Rs. 2 per 100 solid feet	5,286	5	5
21,14,544	Solid feet excavating trench for iron conduit pipe in moorum, at Rs. 0-10-6 per 100 solid feet	13,876	11	1
260	Solid feet excavating foundation of chambered shaft No. 3 in rock, at Rs. 4 per 100 solid feet	10	6	4

ABSTRACT—(*continued*).

Quantities.		Rs.	a.	p.
260	Solid feet excavating foundation of chambered shaft No. 3 in soft rock, at Rs. 2 per 100 solid feet	5	3	2
2,083	Solid feet excavating foundation of chambered shaft No. 3 in moorum, at Rs. 0-10-6 per 100 solid feet	13	10	8
3,040	Solid feet coursed rubble masonry faced with cut-stone, at Rs. 30 per 100 solid feet	912	0	0
27,343	Running feet of iron conduit pipe 13 inches in diameter, at Rs. 4-13-9 per running foot; trenching, &c. not included	1,32,869	14	3
26,43,179	Solid feet filling in trench over aqueduct, at Rs. 0-1-6 per 100 solid feet	2,477	15	8
	Total....Rs...	1,66,024	13	5
	Contingencies, at 5 per cent....	8,301	3	10
	Total amount for iron conduit pipe....Rs...	1,74,326	0	0

RECAPITULATION.

	Rs.	a.	p.
Total amount for the iron conduit pipe..........	1,74,326	0	0
Total amount for the tunnel, as before	11,108	0	0
Total amount for the iron conduit pipe, including tunnel ....Rs...	1,85,434	0	0

No. 7.—DISTRIBUTION RESERVOIR. TWO DAYS' SUPPLY.

MEASUREMENTS.

Excavation.

Section on D. E. F. G. in the centre.

						Solid Feet.
1st portion	....	$\frac{1·90+0·00}{2}$	× 30		28·5	
2nd do.	....	$\frac{4·2+1·9}{2}$	× 12		36·6	
3rd do.	....	$\frac{7·2+4·2}{2}$	× 20		114·0	
4th do.	....	$\frac{7·4+7·2}{2}$	× 13		94·9	
5th do.	....	$\frac{8·0+7·4}{2}$	× 27		207·9	
6th do.	....	$\frac{9·6+8·0}{2}$	× 60		528·0	
7th do.	....	$\frac{10·5+9·6}{2}$	× 22·5		226·12	
8th do.	....	$\frac{3·50+2·5}{2}$	× 12		36·36	
9th do.	....	$\frac{0·75+3·50}{2}$	× 25·5		54·95	
10th do.	....	$\frac{0·00+0·75}{2}$	× 20		7·5	

Section on the east side, at 40 feet from the centre.

1st portion	....	$\frac{1·5+0·00}{2}$	× 23·7	=	17·77	
2nd do.	....	$\frac{3·8+1·5}{2}$	× 12	=	31·80	
3rd do.	....	$\frac{6·8+3·8}{2}$	× 20	=	106·00	
4th do.	....	$\frac{7·00+6·8}{2}$	× 13	=	89·70	
5th do.	....	$\frac{7·6+7·00}{2}$	× 27	=	197·10	
6th do.	....	$\frac{9·2+7·6}{2}$	× 60	=	504·00	
7th do.	....	$\frac{10·1+9·2}{2}$	× 22·5	=	217·12	
8th do.	....	$\frac{3·16+2·1}{2}$	× 12	=	31·02	
9th do.	....	$\frac{0·35+3·16}{2}$	× 25·5	=	44·75	
10th do.	....	$\frac{0·00+0·35}{2}$	× 9·3	=	1·62	
		Total area....			2,575·71	
		Mean area			1,287·855	

1,287·855 × 40 = ... 51,514·20

DISTRIBUTION RESERVOIR—(*continued*).

Solid Feet.

Section on the east side, at 70 feet from the centre.

1st portion	$\frac{0 \cdot 1+0 \cdot 00}{2}$	×	1·6	=	0·08
2nd do.	$\frac{2 \cdot 4+0 \cdot 1}{2}$	×	12	=	15·00
3rd do.	$\frac{5 \cdot 1+2 \cdot 4}{2}$	×	20	=	78·00
4th do.	$\frac{5 \cdot 6+5 \cdot 4}{2}$	×	13	=	71·50
5th do.	$\frac{6 \cdot 2+5 \cdot 6}{2}$	×	27	=	159·30
6th do.	$\frac{7 \cdot 8+6 \cdot 2}{2}$	×	60	=	420·00
7th do.	$\frac{8 \cdot 7+7 \cdot 8}{2}$	×	22·5	=	185·62
8th do.	$\frac{0 \cdot 7+1 \cdot 76}{2}$	×	12	=	10·98
9th do.	$\frac{0 \cdot 00+1 \cdot 76}{2}$	×	15·9		13·99
	Total area.				954·47
	Last area ..				1,240·88
					2,195·35
	Mean area..				1,097·665

∴ 1,097·665 × 30 = 32,929·95

Section taken on the east side, at 136·56 feet from the centre. Same area as the last, 954·47; ∴ 954·47 × 66·56 = ... 63,529·52

Section taken on west side, at 60 feet from the centre.

1st portion	$\frac{1 \cdot 3}{2}$	×	6·8	=	4·42
2nd do.	$\frac{4 \cdot 3+1 \cdot 3}{2}$	×	20	=	56·00
3rd do.	$\frac{4 \cdot 5+4 \cdot 3}{2}$	×	13	=	57·20
4th do.	$\frac{5 \cdot 1+4 \cdot 5}{2}$	×	27	=	129·60
5th do.	$\frac{6 \cdot 7+5 \cdot 1}{2}$	×	60	=	354·00

DISTRIBUTION RESERVOIR—(*continued*).

					Solid Feet.
6th portion	$\frac{7\cdot6+6\cdot7}{2}$	× 22·5	=	160·87	
7th do.	$\frac{0\cdot00+0\cdot66}{2}$	× 37	=	12·21	
		Total area ...		774·30	
		Central area..		1,334·83	
				2,109·13	
		Mean area....		1,054·56	
		1054·565 × 60 =			63,273·90

Section taken on the west side, at 110 feet from the centre

1st portion	$\frac{0\cdot6}{2}$	× 3·1	0·93	
2nd do.	$\frac{3\cdot6+0\cdot6}{2}$	× 20	42·00	
3rd do.	$\frac{3\cdot8+3\cdot6}{2}$	× 13	48·10	
4th do.	$\frac{3\cdot8+4\cdot4}{2}$	× 27	110·70	
5th do.	$\frac{4\cdot4+6\cdot0}{2}$	× 60	312·00	
6th do.	$\frac{6\cdot9+6\cdot0}{2}$	× 22·5	145·12	
		Total area.	658·85	
		Last area .	774·30	
			2| 1,433·15	
		Mean area.	716·575	
		∴ 716·575 × 50 =		35,828·75

Section taken on the west side, at 160 feet from the centre.

1st portion	$\frac{2\cdot8}{2}$	× 18·6	=	26·04
2nd do.	$\frac{3\cdot0+2\cdot8}{2}$	× 13	=	37·70
3rd do.	$\frac{3\cdot6+3\cdot0}{2}$	× 27	=	89·10

DISTRIBUTION RESERVOIR—(*continued*).

Solid Feet.

4th portion	$\frac{5\cdot2+3\cdot6}{2}$	× 60	= 264·00	
5th do.	$\frac{6\cdot1+5\cdot2}{2}$	× 22·5	= 127·12	
		Total area....	543·96	
		Last area	656·15	
			1,200·11	
		Mean area....	600·055	
∴ 600·055 × 27·75 = ...				16,651·52
Total solid feet of excavation in bed of reservoir				2,63,727·84

Portion between Retaining Wall of Reservoir and Parapet Wall surrounding it.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Between retaining and surrounding wall $\overline{133\frac{3}{4}\times2}$+2·5+ (2′4″×2) +(10×2)= 294′8″ 169′8″	1	464·33	8	average 7½	27,859·80
Foundation of wall surrounding reservoir .... 133′9″× 2+2′6″ + $\overline{2'4''\times2}$+(10×2) + (2′4″ ×2)=one side .... 299′4″ other side .... 299′4″ 2. (165+$\overline{2'4''\times2}$)+(9′4″×2) 376′8″	1	965·33	3	3	8,685·00
Portion occupied by retaining wall, north side : (133¾ × 2) + 2·5 + (2′4″ × 2) = ... 274.′8″ Do. do. east and west sides 32 + 14 = ...46.′0″	1	320·66	3	3	2,885·94
			Total solid feet .		39,430·74
			Do.. as above.		2,63,727·84

	Solid Feet.
1-3rd excavating reservoir, taken in hard moorum, solid feet	1,01,052·86
2-3rds do. taken in rock, do.	2,02,105·72
Total solid feet....	3,03,158·58

Filling in Foundation of Uncoursed Rubble Masonry.

	No.	Length.	Breadth.	Depth.	Solid Feet.
For retaining wall of reservoir.	1	320·66	3	3	2,885·94
For wall surrounding reservoir.	1	965·00	3	3	8,685·00
Total solid feet filling in foundation of uncoursed rubble masonry					11,570·94

Building Retaining Wall of Reservoir.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Retaining wall $(133\frac{3}{4} \times 2) + 2{\cdot}5 + (1{\cdot}10 \times 2) \times 2 = 547'\ 4''$ $165 \times 2 =$ .... $330'\ 0''$ $877'\ 4''$ $-52'\ 0''$	*1	$825\frac{1}{3}$*	$\frac{2\frac{1}{4}+1\frac{1}{4}}{2}$	7	10,591·77
Division wall 165—26 = 139	1	139	2·5	7	2,432·50
Cistern walls 26+26+10+10 =72	2	72	3	7	3,024·00
Do. large portions	4	5	2	7	280·00
Do. small do.	4	2	2	7	112·00
Steps	20	6	$\frac{7}{2}$	2	840·00
Total solid feet superstructure of cut-stone masonry					17,280·27

Stone Pavement.

	No.	Length.	Breadth.	Square Feet.
Bottom of reservoir $\overline{133' \ 9'' + 2' \ 10''}$ + 1′ 3″ = 137′ 10″ the length, and 165′ + 2′ 10″= 167′ 10″ breadth .	2	137′ 10″	167′ 10″	46,266·05
Total square feet of cut-stone pavement....				46,266·05

Filling in Earth between Retaining Wall of Reservoir and Wall surrounding it.

	No.	Length.	Breadth.	Depth.	Solid Feet.
North side between the two walls	1	300	8′ 3″	15	37,125·00
Ditto ditto east and west.	1	185	8′ 3″	$\frac{15+10}{2}$	19,078·12
Total solid feet filling in earth between the retaining wall of the reservoir and the wall surrounding it					56,203·12

Wall surrounding Reservoir, of Coursed Rubble Masonry.

	No.	Length.	Breadth.	Depth.	Solid Feet.
North end, lower portion: 133′ 9″ × 2 + 2′ 6″ + 2′ 4″ × 2 + 1′ 8″ × 2 + 4″ = 304′ 4″	1	304′4	2′ 4″	2′	1,420·22
Do. middle do.	1	304′	2′	2′	1,216·00
Do. upper do.	1	304′	1′ 8″	12·07	6,115·46
East side, 1st portion	1	26′ 25	2′ 4″	$\frac{2}{2}$	61·25
Do. 2nd do.	1	31′ 31	2′ 0″	2′	125·24

Wall surrounding Reservoir—(continued).

	No.	Length.	Breadth.	Depth.	Solid Feet.
East side, 3rd portion	1	51′93	1′ 8″	$\frac{2·6}{2}$	112·51
Do. 4th do.	1	128′58	1′ 8″	1	214·30
Do. 5th do.	1	189′66	1′ 8″	7	2,212·70
South side wall	1	304′	1′8″	7·12	3,607·46
West side, 1st portion	1	27′	2′ 4″	$\frac{2}{2}$	63·00
Do. 2nd do.	1	$\frac{27+38·25}{2}$	2	2	130·50
Do. 3rd do.	1	$\frac{38·25+67·5}{2}$	1′ 8″	3	264·37
Do. 4th do.	1	$\frac{67·5+189·66}{2}$	1′ 8″	3·52	754·33
Do. 5th do.	1	189·66	1′ 8″	7·87	2,487·70
Total solid feet..	..	....	....	....	18,785·04
DEDUCT—Doorways	2	4′	1′ 8″	7′	93·33
Total solid feet of coursed rubble masonry in the wall surrounding the reservoir					18,691·71

Filling in Earth to Slope.

	No.	Length.	Breadth.	Depth.	Solid Feet.
North side..............	1	304	80	$\frac{7}{2}$	85,120·00
East side	1	158·5	$\frac{80}{2}$	$\frac{8·8}{2}$	27,896·00
West side	1	193	$\frac{85+8}{2}$	$\frac{8·53+0·87}{2}$	42,180·15
Total solid feet filling in earth to slopes, east, west, and north sides					1,55,196·15

Coping to the Wall surrounding Reservoir.

	No.	Length.	Running Feet.
Coping	1	975′ 4″	975′ 4″
Total running feet cut-stone coping to top of surrounding wall of reservoir			975′ 4″

Doors.

	Number.
Doors teak-wood plank batten 7′×4′................	2
Total number strong teak-wood plank batten doors to reservoir	2

ABSTRACT.

Quantity.		Rs.	a.	p.
1,01,052	Solid feet excavating reservoir in hard moorum, at Rs. 0-14-0 per 100 solid feet	884	3	3
2,02,105	Solid feet excavating reservoir in rock, at Rs. 4 per 100 solid feet	8,084	3	2
11,571	Solid feet filling in foundation of uncoursed rubble masonry, at Rs. 8 per 100 solid feet	925	10	10
17,280	Solid feet of superstructure of cut-stone masonry (coursed rubble masonry faced with cut-stone on the inside), at Rs. 30 per 100 solid feet.	5,184	0	0

ABSTRACT—(*continued*).

Quantity.		Rs.	a	p.
46,266	Square feet of cut-stone pavement, at Rs. 31-8-0 per 100 square feet ..	14,573	12	7
56,203	Solid feet filling in earth between the retaining wall of the reservoir, and the wall surrounding it, at Rs. 1-2-0 per 100 solid feet	632	4	6
18,691	Solid feet of coursed rubble masonry in the wall surrounding the reservoir, at Rs. 9-8-0 per 100 solid feet.	1,775	10	3
1,55,196	Solid feet filling in earth to slopes, at Rs. 1-2-0 per 100 solid feet......	1,745	15	3
975	Running feet of cut-stone coping to top of the wall surrounding the reservoir, at Rs. 1-4-0 per running foot.	1,218	12	0
2	Number of doors of teak-wood plank battened 7′×4′, at Rs. 28 each....	56	0	0
	Total............Rs.	35,080	7	10
	Contingencies, at 5 per cent........	1,754	0	4
	Total amount for distribution reservoir to contain two days' supply ....Rs..	36,834	0	0

DISTRIBUTION RESERVOIR.—ONE DAY'S SUPPLY.

MEASUREMENTS.

Excavation.

Solid Feet.

Section on C. D. through the centre.

1st portion .... $\frac{1{\cdot}90+4{\cdot}2}{2} \times 12 = 36{\cdot}60$

2nd do. .... $\frac{4{\cdot}2+7{\cdot}2}{2} \times 20 = 114{\cdot}00$

DISTRIBUTION RESERVOIR—(*continued*).

							Solid Feet.
3rd portion	....	$\frac{7{\cdot}2+7{\cdot}4}{2}$	×	13	=	94·90	
4th do.	....	$\frac{7{\cdot}4+8{\cdot}0}{2}$	×	27	=	207·90	
5th do.	....	$\frac{8{\cdot}0+9{\cdot}6}{2}$	×	60	=	528·00	
6th do.	....	$\frac{9{\cdot}6+9{\cdot}8}{2}$	×	4	=	38·80	
7th do.	....	5·50	×	3·75	=	20·62	
8th do.	....	$\frac{20{\cdot}5\times2}{2}$			=	20·50	

Section taken on east side, at 40 feet from the centre.

1st portion	....	$\frac{1{\cdot}5+3{\cdot}8}{2}$	×	12	=	31·80	
2nd do.	....	$\frac{3{\cdot}8+6{\cdot}8}{2}$	×	20	=	106·00	
3rd do.	....	$\frac{6{\cdot}8+7{\cdot}0}{2}$	×	13	=	89·70	
4th do.	....	$\frac{7{\cdot}0+7{\cdot}6}{2}$	×	27	=	197·10	
5th do.	....	$\frac{7{\cdot}6+9{\cdot}2}{2}$	×	60	=	504·00	
6th do.	....	$\frac{9{\cdot}2+9{\cdot}4}{2}$	×	4	=	37·20	
7th do.	....	5·1	×	3·35	=	17·08	
8th do.	....	$\frac{1{\cdot}6\times20{\cdot}5}{2}$			=	20·50	
					Total area....	1,003·38	
					2	2,064·70	
						1,032·35	

∴ Mean area 1,032·35 × 40 = solid feet.......... 41,294·00

Section taken on the east side, at 70 feet from the centre.

1st portion	....	$\frac{0{\cdot}1+2{\cdot}4}{2}$	×	12	=	15·00	
2nd do.	....	$\frac{2{\cdot}4+5{\cdot}4}{2}$	×	20	=	78·00	
3rd do.	....	$\frac{5{\cdot}4+5{\cdot}6}{2}$	×	13	=	71·50	
4th do.	....	$\frac{5{\cdot}6+6{\cdot}2}{2}$	×	27	=	159·30	
5th do.	....	$\frac{6{\cdot}2+7{\cdot}8}{2}$	×	60	=	420·00	
6th do.	....	$\frac{7{\cdot}8+8{\cdot}0}{2}$	×	4	=	63·20	

DISTRIBUTION RESERVOIR—(*continued*).

						Solid Feet.
7th portion	....	1·05		5·5	10·72	
8th do.	....	$\frac{0·2\times20·5}{2}$			2·05	
					819·77	
				Last area....	1,003·38	
					1,823·15	
					911·575	
Mean area 911·575 × 30					.	27,347·25

Section taken on east side, at 111·5 feet from the centre.

							Solid Feet.
1st portion	....	$\frac{2}{2}$	×	10·4	=	10·40	
2nd do.	....	$\frac{5+2}{2}$	×	20	=	70·00	
3rd do.	....	$\frac{5+5·2}{2}$	×	13	=	66·30	
4th do.	....	$\frac{5·2+5·8}{2}$	×	27	=	148·50	
5th do.	....	$\frac{5·8+7·4}{2}$	×	60	=	396·00	
6th do.	....	$\frac{7·4+7·6}{2}$	×	4	=	30·00	
7th do.	....	1·5	×	5·5	=	8·25	
8th do.	....	$\frac{1·5\times20·5}{2}$			=	15·37	
						744·82	
				Last area....		819·77	
					2	1,564·59	
						782·295	
Mean area 782·295×41·5 = ...							32,465·24

Section taken on the west side, at 60 feet from the centre.

1st portion	....	$\frac{1·3+0·8}{2}$			=	4·42
2nd do.	....	$\frac{1·3+4·3}{2}$	×	20	=	56·00
3rd do.	....	$\frac{4·3+4·5}{2}$	×	13	=	57·20

DISTRIBUTION RESERVOIR—(*continued*).

					Solid Feet.
4th portion	$\frac{5\cdot1+4\cdot5}{2}$	× 27	=	129·60	
*5th do.	$\frac{6\cdot7+5\cdot1}{2}$	× 60	=	354·00	
6th do.	$\frac{6\cdot9+6\cdot7}{2}$	× 4	=	27·20	
7th do.	0.85	× 5·5	=	4·67	
8th do.	$\frac{0\cdot85}{2}$	× 8·9	=	3·78	
		Total area....		636·87	
		Last area		1,061·32	
			2	1,698·19	
		Mean area....		849·09	

∴ 849·09 mean area × 60 = solid feet........ 50,945·40

Section taken on the west side, at 112·62 feet from the centre.

1st portion	$\frac{0\cdot6}{2}$	× 3	=	0·90	
2nd do.	$\frac{0\cdot6+3\cdot6}{2}$	× 20	=	42·00	
3rd do.	$\frac{3\cdot6+3\cdot8}{2}$	× 13	=	48·10	
4th do.	$\frac{3\cdot8+4\cdot4}{2}$	× 27	=	110·70	
5th do.	$\frac{4\cdot4+6\cdot0}{2}$	× 60	=	312·00	
6th do.	$\frac{6\cdot0+6\cdot2}{2}$	× 4	=	24·40	
7th do.	0·15	×	=	0·82	
		Total area....		538·92	
		Last area		632·45	
				1,171·37	
		Mean area....		585·685	

585·685 mean area × 52·62 = solid feet 30,818·74

Solid Feet.

Excavation for foundation of wall surrounding the reservoir.

Reservoir 201 + (2′ 4″ × 2) + (10 × 2) + (1′ 8″ × 2) = 292 × 2 = ... 458

Reservoir 110 + (2′ 4″ × 2) + (10 × 2) + 134′ 8″ × 2 .... 269·4

727′ 4″

727′ 4″ × 3 × 3 = ... 6,546·00

Solid feet as above	41,294·00
Do.	27,347·25
Do.	32,465·24
Do.	50,945·40
Do.	30,818·74
Do.	6,546·00
Total solid feet excavation	1,89,416·63

Total solid feet excavation.... 1,89,416·63

1-3rd excavating reservoir taken in hard moorum, solid feet .... 63,138·87

2-3rds do. do. taken in rock, solid feet. 1,26,277·76

Total solid feet.... 1,89,416·63

Filling in Foundation of Uncoursed Rubble Masonry.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Wall surrounding the reservoir, 1st offset	1	727′ 4″	3	3	6,546·00

Filling in Foundation—(continued).

	No.	Length.	Breadth.	Depth.	Solid Feet.
Wall surrounding the reservoir, 2nd offset	1	229′ 8″	2′ 4″	7·77	4,163·85
Do. do. east side ..	1	12	2′ 4″	$\frac{2}{2}$	28·00
Do. do. do. ..	1	32	2′ 4″	$\frac{2·8}{2}$	104·53
Do. do. do. ..	1	108′ 8″	2′ 4″	$\frac{2}{2}$	253·55
Do. do. west side ..	1	15	2′ 4″	$\frac{3}{2}$	52·50
Do. do. do. ..	1	45	2′ 4″	$\frac{3}{2}$	157·50
Do. do. do. ..	1	229′ 8″	2′ 4″	$\frac{3·52+·87}{2}$	1,178·95
Total solid feet filling in foundation with uncoursed rubble masonry					12,484·88

Building Retaining Wall of Reservoir.

	No.	Length.	Breadth	Depth.	Solid Feet.
Retaining wall 201 + (2′ 4″ × 2) × 2 = ..411′ 4″ Retaining wall 110 + (2′ 4″ × 2) × 2 = ..229′ 4″ 640·8 Deduct—Cistern wall 52·0 588·8	1	588′ 8″	2′ 4″	1·75	2,403·72
Retaining wall, 2nd offset....	1	588′ 8″	2′ 0″	1·75	2,060·33
Do. 3rd do.	1	588′ 8″	1′ 8″	1·75	1,716·94
Do. 4th do.	1	588′ 8″	1′ 4″	1·75	1,373·55
Cistern walls, 26 + 26 + 10 + 10 = 72 in length	2	72	3	7	3,024·00

Building Retaining Wall—(continued).

	No.	Length.	Breadth.	Depth.	Solid Feet.
Cistern wall pieces at the ends of steps	4	3	2	7	168·00
Steps	12	6	$\frac{7}{2}$	2	504·00
Total solid feet of superstructure of cut-stone masonry ..					11,250·54

Stone Pavement.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Bottom of reservoir	1	206′8″	115′8″	1	23,904·44
Total square feet of cut-stone pavement....					23,904·44

Filling in Earth between Retaining Wall of Reservoir and Wall surrounding it.

	No.	Length.	Breadth.	Depth.	Solid Feet.
North side between the two walls		225′8″	8′3″	10′	18,617·50
Do. east and west sides..		134′7″	8′3″	7′0	15,544·37
Do. south side		225′8″	6′3″	8′0	11,283·33
Total solid feet filling in earth between the retaining wall of the reservoir and the wall surrounding it					45,445·20

Wall surrounding the Reservoir, of Coursed Rubble Masonry.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Wall surrounding the reservoir	1	727′4″	1′8″	7	8,485·55
Deduct—Door-ways	2	4	1′8″	7	93·33
Total solid feet of coursed rubble masonry in the wall surrounding the reservoir					8,392·22

Filling in Earth to Slopes.

	No.	Length.	Breadth.	Depth.	Solid Feet.
North side	1	229	$\frac{122+90+130}{3}$	$\frac{7\cdot0}{2}$	91,371·00
East side	1	138	61	$\frac{7\cdot5}{2}$	31,567·50
West side................	1	138	58	$\frac{8}{2}$	32,016·00
Total solid feet filling in earth to slopes on the N. E. and W. sides					1,54,954·5

Coping to Wall surrounding the Reservoir.

	No.	Length.	Running Feet.
Coping	1	727′4″	727′4″
Total running feet of cut-stone coping to top of surrounding wall of reservoir			727′4″

Doors.

	No.
Doors of teak-wood plank batten 7′ × 4′ to reservoir	2
Total No. of doors of teak-wood plank battened	2

ABSTRACT.

Quantities.		Rs.	a.	p.
63,138	Solid feet excavating reservoir in hard moorum, at Rs. 0-14-0 per 100 solid feet	552	7	3
1,26,277	Solid feet excavating reservoir in rock, at Rs. 4 per 100 solid feet	5,051	1	3
12,484	Solid feet filling in foundation with uncoursed rubble masonry, at Rs. 8 per 100 solid feet	998	11	6
11,250	Solid feet of superstructure of cut-stone masonry, at Rs. 30 per 100 solid feet (coursed rubble masonry faced with cut-stone on the inside)	3,375	0	0
23,904	Square feet of cut-stone pavement, at Rs. 31-8-0 per 100 square feet	7,529	12	1
45,445	Solid feet of filling in earth between the retaining wall of the reservoir, and the wall surrounding it, at Rs. 1-2-0 per 100 solid feet	511	4	1
8,392	Solid feet of coursed rubble masonry in the wall surrounding the reservoir, at Rs. 9-8-0 per 100 solid feet........	797	3	10

ABSTRACT—(*continued*).

Quantities.		Rs.	a.	p.
1,54,954	Solid feet of filling in earth to slopes on the N. E. and west sides, at Rs. 1-2-0 per 100 solid feet........	1,743	3	8
727	Running feet of cut-stone coping to top of surrounding wall of reservoir, at Rs. 1-4-0 per running foot	908	12	0
2	No. of doors of teak-wood plank battened 7′ × 4′, at Rs. 28 each	56	0	0
	Total..Rs....	21,523	7	8
	Contingencies, at 5 per cent.....	1,076	2	9
	Total amount for distribution reservoir to contain one day's supply..	22,599	0	0

No. 8.—CAMP DISTRIBUTION.

MEASUREMENTS.

Excavation for Cisterns 25′ × 18′ × 8′.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Cistern	1	31	24	9	6,696·00
Paving	1	123⅓	5	1	616·66
Total solid feet excavation for cistern 25′ × 18′ × 8′....					7,312·66
½ of excavation for cistern, taken in moorum..........					3,656·33
½ ditto taken in soft rock					3,656·33
Total solid feet....					7,312·66

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Retaining Walls.

	No.	Length.	Breadth.	Depth.	Solid Feet.
1st portion	1	98	3	1	294·00
2nd do.	1	96	2·5	2	480·00
3rd do.	1	94′8″	$2\frac{1}{6}$	2	473·33
4th do.	1	93′4″	$1\frac{5}{6}$	2	342·22
5th do.	1	92′	1·5	2	276·00
Total solid feet of retaining walls of coursed rubble masonry, faced with cut-stone on the inside					1,865·55

Cut-Stone Masonry.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Parapet wall..............	1	91′ 4″	1′ 4″	2′ 9″	334·88
Total solid feet of cut-stone on both sides, including coping..					334·88

Paving.

	No.	Length.	Breadth.	Square Feet.
In the cistern	1	25	18	450·00
Surrounding cistern outside the parapet	1	124	6·5	806·00
Total square feet cut-stone paving....				1,256·00

Excavation for Small Cistern 15′ × 10′ × 8′.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Cistern		21	16	9	3 024·00
Paving		94	5	1	470·00
Total solid feet excavating for small cistern 15′ × 10′ × 8′..					3,494·00
½ excavation for small cistern, taken in moorum					1,747·00
½ do. do. taken in soft rock					1,747·00
Total solid feet....					3,494·00

Retaining Walls.

	No.	Length.	Breadth.	Depth.	Solid Feet.
1st portion	1	62	3	1	186·00
2nd do	1	60	$2\frac{1}{2}$	2	300·00
3rd do.	1	58′ 8″	$2\frac{1}{6}$	2	254·22
4th do.	1	57′ 4″	$1\frac{5}{6}$	2	210·22
5th do.	1	56′	$1\frac{1}{2}$	2	168·00
Total solid feet retaining walls of coursed rubble masonry, faced with cut-stone on the inside					1,118·44

Cut-Stone Masonry.

	No.	Length.	Breadth.	Depth.	Solid Feet.
Parapet wall	1	55′ 4″	1′ 4″	2′ 9″	202·88
Total solid feet of cut-stone on both sides, including coping					202·88

Paving.

	No.	Length.	Breadth	Square Feet.
In the cistern	1	15	10	150
Surrounding cistern outside the parapet	1	88	6·5	572
Total square feet cut-stone paving				722

Distribution Pipes.

	Length.	Running Feet.
Iron pipes 5-inch diameter	23,585	23,585
Iron pipes 4-inch diameter	23,585	23,585
Total running feet 5-inch iron pipes		23,585
Do. 4-inch iron pipes		23,585

ABSTRACT.

Quantities.		Rs.	a.	p.
	Cistern 25′ × 18′ × 8′.			
3,656	Solid feet excavation for cistern in moorum, at Rs. 0-10-6 per 100 solid feet.	23	15	10
3,656	Solid feet excavation for cistern in soft rock, at Rs. 2 per 100 solid feet	73	1	11
1,865	Solid feet retaining walls to sides of cisterns of coursed rubble masonry, faced with cut-stone on the inside, at Rs. 30 per 100 solid feet..........	559	8	0
335	Solid feet of cut-stone masonry on both sides, including coping for parapet, at Rs. 35 per 100 solid feet	117	4	0

ABSTRACT—(*continued*).

Quantities.		Rs.	a.	p.
1,256	Square feet of cut-stone paving to cistern, at Rs. 31-8-0 per 100 square feet	395	10	2
	Total....Rs..	1,169	7	11
	Contingencies, at 5 per cent.....	58	7	7
	Total amount for the cistern 25′ × 18′ × 8′........................	1,227	0	0
	Cistern 15′ × 10′ × 8′			
1,747	Solid feet of excavation for cistern in moorum, at Rs. 0-10-6 per 100 solid feet	11	7	5
1,747	Solid feet excavation for cistern in soft rock, at Rs. 2 per 100 solid feet....	34	15	0
1,118	Solid feet of retaining walls to sides of cistern, of coursed rubble masonry, faced with cut-stone on the inside, at Rs. 30 per 100 solid feet	335	6	4
203	Solid feet of cut-stone masonry on both sides, including coping for parapets, at Rs. 35 per 100 solid feet	71	0	9
722	Square feet of cut-stone paving to cisterns, at Rs. 31-8-0 per 100 square feet	227	6	10
	Total....Rs..	680	4	4
	Contingencies, at 5 per cent.........	34	0	3
	Total amount for the cistern 15′ × 10′ × 8′ ..	714	0	0

ABSTRACT.

Quantities.		Rs.	a.	p.
23,585	Running feet of 5-inch iron pipes, including trenching, hydrants, &c., at Rs. 1-7-8 per running foot	34,886	2	4
23,585	Running feet of 4-inch iron pipes, including trenching, hydrants, &c., at Rs. 1-2-7 per running foot	27,392	15	11
	Total....Rs..	62,279	2	3
	Contingencies, at 5 per cent........	3,113	15	3
	Total amount for camp distribution pipes....Rs..	65,393	0	0

RECAPITULATION OF THE CAMP DISTRIBUTION.

	Rs.	a.	p.
Cisterns 24 in No., at Rs. 1,227 each	29,448	0	0
Cisterns 12 in No., at „ 714 each	8,568	0	0
Iron pipes for the camp distribution	65,393	0	0
Total amount for the camp distribution	1,03,409	0	0

GENERAL RECAPITULATION OF THE ESTIMATE.

No.		Rs.	a.	p.
1	The embankment........................	1,52,064	0	0
2	The waste weir.........................	10,517	0	0
3	The artificial cut to carry off the first floods.	24,651	0	0
4	The inlet tower.......................	12,172	0	0

GENERAL RECAPITULATION—(*continued*).

No.		Rs.	a.	p.
5	The gangway	9,082	0	0
6	The masonry aqueduct and tunnel	1,14,969	0	0
,,	The iron conduit pipe and tunnel	1,85,434	0	0
7	The distribution reservoir, to contain two days' supply	36,834	0	0
,,	The distribution reservoir, to contain one day's supply	22,599	0	0
8	The camp distribution	1,03,409	0	0

(Signed) PHILIP L. HART, Captain,
Engineers, on Special Duty.

Camp Poona, 23rd October, 1857.